Selective Fisheries

Review & Evaluation

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January 1999

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Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Introduction [Return to Selective Fishing]

On May 21, 1998 the honourable David Anderson, Minister of Fisheries and Oceans, announced far-reaching conservation objectives for the Pacific salmon fishery.

> *Based on the need for immediate action to protect and rebuild coho stocks, and consistent with scientific advice, I am announcing the following two conservation objectives: there will be zero fishing mortality for critical upper Skeena and Thompson coho stocks. And where upper Skeena and Thompson stocks are not prevalent, I will entertain proposals for selective fisheries which can demonstrate that the risk of coho bycatch mortality will be minimal.*
>
> *The Minister noted these objectives will guide the development of harvesting management plans for 1998 and beyond. Their adoption will have profound implications for the way we conduct the salmon fishery.*[1]

This announcement marked a fundamental change in the management and conduct of the Pacific salmon fishery.

> *The 1998 salmon management plan will introduce a fundamental new direction for the management of the Pacific salmon fishery.... (S)elective, conservation-based fishing techniques are being introduced to conserve coho and other stocks at risk. Selective fishing is a cornerstone for conservation-based management and for a sustainable fishery for the future.*[2]

So began a new phase in the history of British Columbia's salmon fishery. The Minister's conservation measures, including selective fishing experiments, were indeed implemented in the 1998 salmon management plan.

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[1] DFO (1998g), p. 1, emphasis added.

[2] DFO (1998l), p. 1.

The coast was divided into areas where upper Skeena and Thompson River coho are prevalent (red zones) and not prevalent (yellow zones). The 1998 fishing plan has two principal objectives for coho salmon: (1) targeting for zero fishing mortality for critical upper Skeena and Thompson River coho stocks; and (2) in yellow zones, fisheries must be selective and demonstrate that the risk of coho by-catch mortality on other stocks will be minimal. Selective fishing means that salmon fleets must adapt their traditional practices and gear to ensure that non-target species are avoided or, if caught, released alive and in good condition. There is non-retention and non-possession of coho during all fisheries in 1998.

In the aboriginal fishery, DFO will consult with First Nations regarding food, social and ceremonial needs, considering measures to avoid or minimize coho by-catch in First Nations' fisheries. Pilot sales fisheries will take place in the lower Fraser River until coho are present in late August, and in the Somass River on the west coast of Vancouver Island. In the Skeena River, pilot sales fisheries will occur in Babine Lake and the mainstem of the Skeena River. There will be no expansion of ESSR fisheries for sales purposes.

In the sport fishery, barbless hooks must be used when fishing for salmon everywhere on the coast. In yellow zones, fishing is permitted. In red zones, salmon fishing is restricted but fishing for other species of finfish and harvest of shellfish is permitted. Small nearshore areas will be open to carefully monitored salmon fishing to determine if selective fishing for salmon other than coho can be conducted. Monitoring by independent observers will be employed to evaluate the ability to avoid encounters with coho. If coho are encountered to any significant degree in these small experimental fisheries, they will be moved or closed. Terminal fisheries on hatchery coho will be permitted in areas such as the mouth of and in the Capilano and Qualicum Rivers, and in the Chilliwack and Chehalis Rivers.

In the commercial fishery, limited experimental fishing using modified gear, fish traps and fish wheels will be considered in red zones. In yellow zones, use of modified gear will be permitted but coho by-catch will be minimized. All fisheries will be subject to more catch monitoring than in the past, and fishing times and areas will be adjusted based on coho by-catch concerns. Revival boxes are required and all coho captured accidentally must be released to the water with the least possible harm. Seines are required to brail (dipnet)

their catches out of their nets. Some traditional fishing areas were closed.

Selective fishing measures aimed at avoiding or reducing the incidence of catching coho and increasing survival rates upon capture are specific to gear type:

Seine fleet

- mandatory brailing and sorting.
- hot spot closures (e.g. no fishing in coho abundance areas).
- timing closures (e.g. no fishing at times of coho abundance).
- specially designed brailers with knotless web to reduce scaling.

Gillnet

- hot picking (30 minute sets) of nets.
- hot spot closures (e.g. no fishing in coho abundance areas).
- timing closures (e.g. no fishing at times of coho abundance).
- reduced fishing periods (e.g. daylight fisheries or shortened days).
- cutting meshes from entangled coho before releasing.

Troll

- barbless hooks.
- hot spot closures (e.g. no fishing in coho abundance areas).
- timing closures (e.g. no fishing at times of coho abundance).
- test fishing prior to fisheries.
- use of plugs only for any summer chinook fisheries.

DFO retained Edwin Blewett & Associates Inc and Timothy Taylor Consulting Services Inc to prepare a report on selective fisheries. The terms of reference for the report required preparation of recent historical material on selective fishing measures and development of a policy framework for selective fisheries. Selective fishing measures were to be evaluated in terms of readiness for implementation, and recommendations provided for 1999 on selective fishing measures and priorities for new gear and methods.

Chapter 2 reviews recent developments in the BC salmon fishery. Chapter 3 presents an overview of selective fishing measures—prac-

tices and technology. Selective fishing measures are evaluated in Chapter 4.

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Background [Return to Selective Fishing]

In this section, we review recent developments that have determined the context into which selective fishing has been introduced.

Missing Fish

Twice in the 1990s fish have "gone missing." In 1992, 482,000 sockeye salmon "seemed to disappear on their way to spawning grounds in the Fraser River system."[1] In September 1994, DFO announced that "spawning escapement estimates plus aboriginal catch estimates for Early Stuart, Early Summer and Summer runs were 1.3 million lower than the number of sockeye anticipated, based on Pacific Salmon Commission estimates at Mission."[2]

In both cases, the Minister of Fisheries retained independent advisors to sort out the problems and make recommendations on how best to avoid their re-occurrence and improve management of the salmon fishery.

In 1992, Dr Peter Pearse concluded that "the shortfall in spawners was due mainly to unusually intensive fishing in the river last summer (and) significant losses can also be attributed to fishing-induced mortality—dead fish dropping out of nets and fish dying of stress after escaping from nets."[3]

Dr Pearse's recommendations relevant to the conservation crisis and the introduction of selective fishing include:

- Commitment to conservation by all participants: "virtually everyone pays lip service to this notion. But each has a tendency, when the resource is under pressure, to resist bearing the burden of restraint and to blame others."

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[1] Pearse (1992), p. 3.

[2] Fraser River Sockeye Public Review Board (1995), p. 11.

[3] Pearse (1992), p. 3.

- Fishermen and managers must be accountable: "government has an obligation to make its policy clear and to communicate with those affected. This includes the public servants expected to administer the policy; they must be given direction when they need it, not left unsure as they were last summer (1992)."

- Strict enforcement: "When offenders are not punished, more offences often result. ... Any new agreements must have strong enforcement."

Fraser River Sockeye Public Review Board

Following the second incidence of missing fish in 1994, the Minister of Fisheries and Oceans established the Fraser River Sockeye Public Review Board. Its findings were dramatic.

> *If something like the 1994 situation happens again, the door to disaster will be wide open. According to what the Board found, one more 12-hour opening could have virtually eliminated the Late run of sockeye in the Adams River. Such an occurrence would have devastating consequences for the Pacific (salmon) fishery, delaying stock rebuilding efforts by years and bringing dire economic consequences to the province. The Board believes that the solution to this problem lies in fixing the system. Unless all parties work together and manage much more competently the tragedy that befell the Atlantic cod fishery will repeat itself here.*[4]

The road to selective fishing may be said to start from the report of the Fraser River Sockeye Public Review Board. The Public Review Board made 35 recommendations, the most important of which for our purposes are listed below:

- We recommend that DFO retain and exercise its constitutional conservation responsibilities and not in any way abrogate its stewardship of resources under federal jurisdiction. Conservation must be the primary objective of both fisheries

[4] Fraser River Sockeye Public Review Board (1995), p. xii.

managers and all others participating in the fishery. The conservation ethic must prevail throughout and be adhered to by all.

- We recommend that DFO take immediate steps to initiate a process of planning for the future of the fishery, addressing all critical problems affecting conservation and sustainability, through an ongoing consultative forum. Among the problems to be considered would be over-capitalization, user-group allocation and ensuring equitable treatment under the law.

- We recommend that DFO and PSC adopt a risk aversion management strategy....

- We recommend that DFO...implement a revised system to ensure that catch information is timely and reliable.

- We recommend that DFO develop better co-ordinated inter-party communications among its staff and between its staff and PSC, First Nations, commercial and recreational fishing groups, with a greater degree of cooperation aimed at enhanced in-season management and post-season evaluation and at fostering closer working arrangements among all parties, and facilitate clearer and more transparent management and allocation policies.

- We recommend that DFO, the Pacific Salmon Commission, First Nations and user groups institute a formalized pre-season review of each season's management plans and strategies, to be followed by a post-season performance analysis.

- We recommend that industry participants in the salmon fishery develop and implement in conjunction with DFO a self-sustaining, user-pay landing verification system, as already exists in other West Coast fisheries (eg, halibut, sablefish, groundfish).

Pacific Policy Roundtable

The report of the Fraser River Sockeye Public Review Board recommended that a consultative forum begin planning the future of the

salmon fishery, addressing issues such as intersectoral allocation and overcapitalization. The Minister of Fisheries and Oceans accepted this recommendation and set up a series of discussions among stakeholders known as the Pacific Round Table.

To guide the work of the Pacific Round Table, the Minister of Fisheries and Oceans provided three principles:

1. Conservation: to conserve and protect the fisheries resource and its habitat in trust for future generations.

2. Economic viability: to ensure the best use of the resource. The fishery must be economically viable and organized around sound business principles; it must be capable of providing a living for its participants and be able to contribute to the Canadian economy on a self-reliant basis.

3. Partnership: to create a joint vision for the Pacific fisheries with stakeholders and to share responsibility for resource development and fishery management, including management costs, decisions and accountability.

The meetings of the Pacific Round Table produced a report to the Minister on the Renewal of the Commercial Pacific Salmon Fishery. The government's response to that report, announced on March 29, 1996, was the Pacific Salmon Revitalization Strategy (the Mifflin Plan).

The May Report

In January 1996, in response to a recommendation of the Pacific Policy Roundtable an independent advisor to the Minister of Fisheries and Oceans, Dr Art May, was appointed to provide advice on intersectoral allocation. Dr May's investigation focussed on initial shares for each sector and a process to allow adjustments among sectors. In the course of his discussions with the sectors, Dr May noted "one clear issue on which there is wide consensus. All appear to accept, and indeed many strongly advocated, the need for conserva-

tion and the appropriateness of it taking priority over other considerations."[5]

> *While this paramountcy of conservation is a given in the Terms of Reference, it is comforting to know that no one questions that priority. It is also important to have a strong definition of conservation. Conservation should be defined using the language which has evolved for sustainable development generally, i.e., to the effect that nothing we do should foreclose the options of future generations to decide for themselves. We should not foreclose future options on species and stock mix. We should be concerned about maintenance of gene pools. We should favour selective fisheries, wherever that is practically possible.*[6]

The Toy Report

In 1997 Judge Samuel Toy was appointed independent advisor on intersectoral allocation of Pacific salmon to the Minister of Fisheries and Oceans, with the objective of arriving at a consensus on the implementation of policy issues recommended by Dr May. Mr Toy's findings include widespread opposition to ITQs in the salmon fishery, and widespread support, except among First Nations, for government paying compensation to buy back commercial shares of allocations equivalent to treaty allocations, but no clear consensus on any other issues.

Mr Toy also managed to oversee a negotiation process between commercial and recreational fisheries interests that produced something of a consensus document entitled "Managing Change" the contents of which he then adopted, subject to some minor qualifications, as his first recommendation to the Minister.

"Managing Change" contains the following recommendations:

- The recreational fishery should continue to be managed by DFO based on the application of reasonable limits. The allo-

[5] May (1996), p. 11.

[6] May (1996), p. 11.

cation of the recreational sector, in other words, would not be a fixed number calculated pre-season, but rather the department's estimate of the total catch to be derived from the application of the chosen limits.

- In years of low abundance, it may be necessary to reduce allocations of chinook and coho targeted by the commercial fishery to ensure that the recreational sector is "last on the water." The commercial sector would continue to receive minimum allocations of these species as bycatch mortalities to maintain fisheries on target species.

- Average catches in the years 1991-94 provide useful base period numbers against which to measure allocation changes over time. An area-by-area examination is required to guard against anomalous circumstances.

- Short term allocation changes should be subject to compensation paid by the federal government into a trust fund to be used to support the economic viability of the commercial sector. Compensation for permanent allocation changes should be directed towards reducing harvesting and processing capacity.

- Compensation for allocation transfers from the commercial to the recreational sector should not be financed by increasing license fees in the recreational sector.

Mr Toy's second and last recommendation was that the Minister should,

> *create a new initiative the object of which is the empowering of regional management boards throughout the entire province, democratically elected, with an overarching independent tribunal. The purpose of these new creations will be to formulate, advise and undertake local conservation and habitat enhancement programs, co-ordinate and present preseason fishing plans, assist with in-season management and if as and when appropriate, the determination of inter and intrasectoral*

allocations and/or reallocations by an overarching independent tribunal.[7]

The Kelleher Reports

Mr Stephen Kelleher began mediating a 1997-2000 Long Term Allocation Plan (LTAP) for commercial gear groups in 1996. In his first report[8] Mr Kelleher made the following observations relevant to selective fisheries policy.

- DFO has stated that catches in the north and south licensed areas should generally be dependent on and proportional to production of stocks from each area. Over the next four years (1997-2000), expected catch in the north is much less than in the south. Northern area license holders should not expect allocations of southern bound stocks to make up any shortfall if the abundance of north coast stocks fails to meet the expectations of license holders.

- The 1991-1994 Long Term Allocation Plan contained a catch-up/make-up arrangement for Fraser River sockeye salmon. While respecting this arrangement in the 1991-1994 LTAP, Mr Kelleher recommended that the principle of coast-wide catch-up/make-up (for Fraser River sockeye) not be continued in the 1997-2000 Allocation Plan.

- Mr Kelleher does favour, in principle, a well-defined mechanism to address discrepancies between the allocation plan and the actual catch in sockeye equivalents at the end of the four year plan. Recognizing that the principles of conservation and manageability make it difficult to simply impose such a mechanism, he recommended that details of a variance and adjustment mechanism be developed during discussions of detailed sharing arrangements.

Mr Kelleher noted the following areas of general consensus:

- Allocation should cover all five species of salmon.

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[7] Toy (1998), p. 27.

[8] Kelleher (1997), p. 4.

- Sockeye equivalents should be used as the unit of measurement.
- Allocations should where possible reflect traditional fishing patterns.
- Allocations should be considered on a four year cycle.

He recommended that the consensus on these issues be respected and that the long term allocation plan be based on all five species, measured in sockeye equivalents, that allocations where possible reflect traditional fishing patterns, and that allocations be considered on a four year cycle.

At the request of Minister Anderson, Mr Kelleher resumed his work late in 1997, with a view to providing a "well-defined 1998-2001 LTAP". After further deliberations and mediations, he made additional observations and recommendations, the following among them:

- Stakeholders voiced a number of objections to the allocation principle that the allocation plan reflect, where possible, traditional fishing patterns. There are those who feel traditional fishing patterns have been rejected in practice and are no longer an established allocation principle. There are others who feel that the principle is used in practice but should not be. In the former group are northern gillnetters and trollers who "traditionally" harvested Fraser River sockeye salmon in Areas 1 and 2W who argue that this practice has been subordinated to the objective of area licensing to focus the efforts of harvesters on stocks originating in their own license area. Similarly, some southern gillnetters and seiners cite reallocation of sockeye to the troll fleet to replace their traditional catch of coho and chinook as another example of the apparent rejection of traditional fishing patterns. Finally, some seiners and processors have argued that traditional fishing patterns should not be part of Pacific fisheries policy, however it was used in the past, because the fishery must be able to evolve to meet the demands of the market place.

There is a high degree of consensus among stakeholders in the salmon fishery that no new selective fisheries should be established without formal re-allocation, accurate retirement of commercial fleet capacity and appropriate compensation. Many stakeholders believe

that a gear unable to catch its allocation because it is not selective should be given the first opportunity to catch that allocation using a modified gear. These stakeholders further advise that DFO should concentrate not on old technologies such as fish traps and wheels, but on improving the selectivity of gear types presently in use.

- Agreement was similarly strong on the issue of accounting for selective catch. Most stakeholders express the view that DFO should not contemplate any new fisheries, believing that the resource is already fully subscribed and cannot therefore support further users. Other stakeholders concede that such fisheries might be contemplated but that no new extra-commercial fisheries should be contemplated without an express buy-out of commercial capacity.

- Across gear groups, there are stakeholders who believe that the fleet is still too large. Estimates of the reduction in fleet size still required range up to 50 percent.

Mr Kelleher goes on to make the following recommendations:

- Formal adjustments for deficits and surpluses be suspended until after area re-selection is complete (at the start of 2000 for that fishing season).

- The department should continue its efforts to improve catch accounting and monitoring systems with a view to improving confidence in catch statistics.

- A by-catch of Fraser River sockeye be included in formal allocation accounting once every four years.

- By-catch of Fraser River sockeye in the north be deducted from the TAC of the same gear group in the south in-season.

- The LTAP not be adjusted after the 1999 area re-selection process.

- An allocation facilitator be appointed to handle disputes.

Mr Kelleher makes specific recommendations regarding selective fisheries.

- DFO should consider no new selective fisheries without accurate retirement of commercial fleet capacity and appropriate compensation.

- In the interests of encouraging commercial license holders to innovate, and providing them with an opportunity to catch their allocation in new, more selective ways, DFO should establish a program to consider applications from commercial license holders for trial harvests by more selective means.

Pacific Salmon Revitalization Strategy

The major components of the Mifflin Plan include: risk-averse management; a targeted 50% reduction in the number of boats in the fleet over the long term; an $80 million voluntary license-retirement program; single-gear licensing; division of the coast into two areas for seine fishing and three each for gillnet and troll fishing; license stacking (ie, fishing more than one area or gear from a single vessel); revamping the consultative process; and addressing the allocation dispute.

The Mifflin Plan was successful in reducing the number of licensed vessels in the fishery. Fleet size dropped about 20% through license retirement and another 15% through license stacking. This might have been enough except that landed volumes fell dramatically in 1995 and have since remained at unprecedented low levels. The average catch in 1995-97 was about one-half its average level during the preceding decade (1985-94). Catches in all three years were lower than the previous record low of 50,000 tonnes recorded in 1984. Harvests to October 31, 1998 total 19,076 tonnes.

In the context of the semi-collapse of the Pacific salmon fishery since 1995, the Mifflin Plan did not go far enough. Recent reports have concluded that further restructuring is needed to develop a sustainable fishery. In a report commissioned by the BC Fisheries Minister, Parzival Copes states that, "the need for reduction in the size of the salmon fleet is beyond dispute." Similarly, a report commissioned by the BC Jobs Protection Commissioner concluded that, "the industry as we know it today will not survive unless fundamental change is embraced and implemented. Further restructuring at both the harvesting and processing level is needed." His report concludes that,

the last three years have seen terrible financial results for the fleet, with low catches and low prices. However, as bad and unprecedented as the 1996 and 1997 seasons were from a financial standpoint, they would have been significantly worse in the absence of the federal fleet reduction program. ... It appears that only another fleet reduction—in the order of about 900 vessels and 1,100 licenses under the Mid-Low catch projections, and 1,500 vessels and 1,900 licenses under the Low catch projection—or some other significant change to fisheries management or business practices can improve long-term viability of the sector.[9]

Selective Fisheries Approach

On May 12, 1998, the Coho Response Team (CRT) issued its *Selective Fisheries Approach for Management of BC Salmon Fisheries in 1998*. In that document, the CRT lays out a Selective Fisheries Management Framework (SFMF) and new salmon fishery management options involving near-zero (coho) mortality and selective fishing techniques.

The SFMF includes a number of provisions:

- Defining allocation priority over salmon species more explicitly, namely allocating priority for chinook and coho salmon to the recreational fishery and allocating priority for sockeye, pink and chum salmon to the commercial fishery.
- Proposed definitions of selective fisheries (ie, "live release" and "no encounter or live release").
- Allocation arrangements to follow the Kelleher recommendations, recognizing that it may be difficult to meet allocation targets given the need for stringent coho conservation measures.

[9] DFO (1998ff), p. 2-3.

Conservation Objectives

On May 19, 1998 the Minister of Fisheries and Oceans announced conservation objectives to protect and rebuild west coast stocks of coho salmon, as well as consultations to develop ways to implement conservation directives for the 1998 salmon season and beyond. Minister Anderson announced two conservation objectives:

- Zero fishing mortality for critical upper Skeena and Thompson River coho stocks.
- Where upper Skeena and Thompson coho stocks are not prevalent, proposals for selective fisheries capable of demonstrating a minimal risk of coho by-catch mortality will be entertained.

The Minister noted that these objectives will guide the development of harvesting management plans for 1998 and beyond.[10]

Coho Recovery Plan

On June 19, 1998 the Minister of Fisheries and Oceans announced Canada's Coho Recovery Plan and $400 million of funding.

- $100 million for a new habitat fund to provide financing for habitat protection and restoration, watershed stewardship and salmon enhancement in perpetuity.
- $200 million to support development of selective fisheries, voluntary license retirements, and diversification of commercial fisheries
- $100 million to help people and communities adjust to the significant changes that are and will be taking place.

[10] DFO (1998g), p. 1.

Responsible Fishing

The Canadian fishing industry has developed a *Code of Conduct for Responsible Fishing Operations* as an essential step in the achievement of sustainability of (marine and freshwater) fisheries. The Canadian Code outlines general principles and guidelines for commercial fishing operations that take place in Canadian waters. Implementation of the Code is expected to contribute directly to conservation of stocks and protection of the aquatic environment. The Code is not intended to justify or impose any allocation or sharing arrangements; these are separate issues.

The *Canadian Code of Conduct for Responsible Fishing Operations* includes nine principles, which are paraphrased below.

- Responsible management and harvest of aquatic resources and their habitats to ensure sustainability.
- Ecological sustainability of Canadian fisheries, taking into account the economic importance of fisheries to industry participants and their communities.
- Shared responsibility and cooperative spirit among industry participants and management agencies.
- Adoption of specific mechanisms and regulations as required by fish harvesters to address problems in Canadian fisheries.
- Balance the level of fishing effort with the sustainable supply of fisheries resources.
- Minimize unintended by-catch and reduce waste and adverse impacts on marine ecosystems and their habitats.
- Develop, maintain and promote public awareness and understanding of responsible fishing issues and measures taken by fish harvesters to conserve stocks and protect the environment.
- Promote recognition of specialized knowledge of fish harvesters and integration with scientific analyses and fisheries management policies and regulations.

- Conduct harvesting operations in accordance with Canadian fisheries law and regulations, international laws, regulations, conventions, declarations and protocols adopted by Canada, and harvesting plans adopted by each fishery.

Each principle in turn is supported by a number of guidelines that are too numerous to list here.[11]

The Code will be managed by an Industry Board reflecting the character and nature of Canada's fishing industry. The Board will oversee the ratification of the Code; conduct annual meetings to address proposals for changes to the Code; oversee ongoing activities in its support; and represent the Code in dealings with Canadian government agencies and international bodies.

In 1998, DFO's Responsible Fishing Operations unit oversaw the production of booklets containing guidelines for conducting selectivity experiments in BC commercial purse seine, troll and gillnet salmon fisheries, as well as one on comparing braillers in purse seine fisheries. These booklets will be useful to license holders submitting proposals to conduct selective fishing experiments in 1999.

New Directions Policy

In October 1998, DFO published its policy paper, *A New Direction for Canada's Pacific Salmon Fisheries*. The New Directions document presents new policy principles under three headings:

- Conservation
- Sustainable Use
- Improved Decision Making

Principles enunciated in the New Directions policy include:

- Conservation is the primary objective, taking precedence over all other objectives.

- Pre-cautionary approach to fisheries management

[11] Canadian Code of Conduct for Responsible Fishing Operations (1998), p. 7-15.

- Net gain in productive capacity of salmon habitat in British Columbia.
- Ecological approach to fisheries and oceans management.
- Trade-offs between current harvest benefits and long-term stock well-being will be resolved in favour of the long term.
- All sectors will use selective methods to harvest salmon.
- First Nations' FSC requirements will have first priority after conservation.
- The recreational fishery will be provided with more reliable and stable fishing opportunities whenever possible.
- The commercial fishery will become more diversified and economically viable.
- Information on major issues requiring decisions will be provided to the public, and periodic review of progress and achievements will be initiated to facilitate accountability
- Government and stakeholders together will be responsible and accountable for sustainable fisheries.
- Community, regional and sector-wide input decision making will be enhanced through a structured system of management and advisory boards.

Allocation Framework

In December 1998, DFO released *An Allocation Framework for Pacific Salmon: 1999-2005*. Building on the introduction of selective fishing, the Coho Recovery Plan, and the *New Directions* paper, the Allocation Framework lays out seven principles designed to guide salmon allocation decisions until at least 2005. These principles include:

- **Conservation**: conservation of Pacific salmon stocks is the primary objective and will take precedence in managing the resource—conservation will not be compromised to achieve salmon allocation targets.

- **First Nations:** after conservation needs are met, First Nations' food, social and ceremonial requirements and treaty obligations to First Nations have first priority in salmon allocation.

- **Common Property Resources:** salmon is a common property resource that is managed by the federal government on behalf of all Canadians, both present and future.

- **Recreational Allocation:** after conservation needs are met, and priority access for First Nations is addressed, recreational anglers will be provided priority to directed fisheries on chinook and coho salmon, and predictable and stable fishing opportunities for sockeye, pink and chum salmon.

- **Commercial Allocation:** after conservation needs are met, and priority access for First Nations is addressed, the commercial sector will be allocated at least 95 percent of combined commercial and recreational harvest of sockeye, pink and chum salmon, and commercial harvest of chinook and coho salmon will occur when abundance permits.

- **Selective Fishing:** to encourage selective fishing, a portion of the total available commercial catch will be set aside for existing commercial license holders to test alternative, more selective harvesting gear and technology and, over time, commercial allocations will favour those that can demonstrate their ability to fish selectively.

- **Gear Allocations:** target allocations for the commercial sector will be established coast-wide by gear with catch of all species expressed in terms of sockeye equivalents, subject to adjustments over time to account for conservation needs including selective fishing and possible changes resulting from the Salmon License Retirement Program.

The Allocation Framework also promises the establishment of an independent board with coast-wide responsibilities to advise and assist the Minister in implementing salmon allocation policy.

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Selective Fishing Measures

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In this section of the report, we review the techniques of selective fishing. These are the practices and technologies that enable harvesters to catch target species without killing non-target species or, in some cases, avoid encountering non-target species entirely. Collectively, these different techniques—including modifications of existing gear, re-introduction of very old fishing technologies and experimentation with entirely new means of harvest—are referred to as Selective Fishing Measures. We discuss Selective Fishing Measures (SFMs) in three parts.

First, we discuss the very old technologies used by First Nations and others fishing in the earliest part of this century that may have potential for use as future SFMs.

Second, we look at a new wave of experimentation with SFMs that began within the past five years. A range of factors motivated projects undertaken during this time, but key among these was a growing concern about steelhead interceptions during the prosecution of sockeye fisheries. The SFMs of this period include modifications to existing fishing gears and work with fishing technologies such as fishwheels, weirs, traps and beach seines.

Third, we look at the unique fishing season just completed—the 1998 season—during which a range of new selective fishing projects were approved by DFO. Each of these projects involved the testing of one or more SFMs. Some involved modified conventional gear, others involved old technologies as described above, still others involved experimentation with new ideas for selective salmon harvest.

Taken in total, this section offers a summary of SFM experimentation over time, with a significant focus on the last 3-5 years. Technologies are described and, where information is available, outcomes are summarized. It has not been possible to offer a complete technical evaluation of each project. Not all of the experiments described have been evaluated for their selectivity (not all projects over the past 5 years have had formal mortality studies carried out on non-targeted encounters), and the implementation and evaluation of

1998 experiments is still underway at the time of writing. Still, a description of each project is offered, and comment is provided where possible on the status and likely promise of the technology involved.

Historical Technologies

The historic fishing methods discussed in this section are fish traps, reef nets, fish wheels, beach seines and dip nets. Each of these was used historically in the Pacific Northwest, typically by First Nations but also by commercial harvesters in some cases. Other techniques were also used, but we focus on these because they lend themselves to live-capture, and therefore selectivity.

Different technologies were favoured on different parts of the coast. Fraser River First Nations used dip nets and fish traps, for example.[1] Reef nets were more common among Puget Sound peoples and the First Nations of south Vancouver Island.[2] This highlights the very site-specific nature of SFMs, a key point that comes up frequently in this discussion.

Fish Traps

Two categories of fish trap are discussed here: pile traps and floating trap nets. In either case, the fish trap is a passive fishing device that sits in the path of migrating fish. Fish are funnelled into the trap by one or more lead nets. Once in the trap, fish are guided through a series of smaller and smaller chambers in the trap, and finally into a holding net, or spiller. From there, fish can be harvested by dip net, by raising the spiller out of the water, or by other means. In the case of a pile trap, the structure of leads and net chambers is mounted on piles which are driven into the ocean or river floor. In the case of a floating fish trap, leads and chambers are suspended from floats on the surface of the water and the entire net structure is held in place by anchors. Different trap types were developed in response to site specific factors such as tidal flow and ocean floor characteristics. Historically, pile traps were more common over sandy bottoms in

[1] Bennett (1973).

[2] Curry (1998a).

southern BC while floating traps were more common over the rocky sea beds of southern Alaska.

Fish traps have a long history in the Pacific Northwest. They were used by First Nations in various parts of the province and were steadily adapted for use in commercial fisheries in the late 1800s. By the early twentieth century, commercial use of pile and floating traps had greatly expanded, with 163 traps in Washington State supplying 15 canneries and over 400 floating traps and 276 pile traps harvesting in southeastern and central Alaska.[3]

A trap net mounted on piles of the type used in the T'sou-ke area. Photo: BC Archives

The first commercial use of a trap was on the Columbia River in 1879, but a trap targeting Fraser stocks—situated at Cannery Point—was built just a year or two later. In 1894, traps were legally approved for use in British Columbia, motivated in part by a desire to put BC harvesters on an equal footing with net owners in the State of Washington.[4] Two experimental traps were approved in Boundary Bay, although they did not live up to expectations. A range of objections to traps, some politically motivated, resulted in a general ban being re-imposed by Canadian fisheries authorities in 1901.

Concern about American harvests of Fraser stocks continued to grow in the early years of the twentieth century. Traps were eventually re-authorised in Boundary Bay and in the waters of Juan de Fuca Straight in 1904 causing controversy and dispute. Over 30 applica-

[3] Triton Environmental Consultants Ltd. (1992), Curry (1998a) and Stewart (1977).

[4] Curry (1998a).

tions were made by cannery operators for licenses to operate traps; a smaller number was actually tried. The most successful and lasting of these were pile traps in the Sooke area of Juan de Fuca Strait. The largest of these required 320 pilings between 10 and 45 metres in length. Wire netting was used for the lead and outer trap chambers, cotton webbing was used for the inner chambers and the spiller. Over time, Sooke became the centre of commercial trap operations in the region as Washington State banned trap nets in 1935.

Floating trap activity continued in Alaska over this period but was increasingly controversial. In 1936, when the largest salmon pack was canned in Alaska, it is estimated that traps caught 66 million fish for canning while purse seines took 34 million. Opposition to traps grew and, allowing only a few aboriginal exemptions, the State of Alaska banned their use in 1959.[5]

Sooke commercial trap operations continued up to the same year when "...restricted fishing times, expectations for poor salmon runs, increased costs of operation and the development of the modern seine fleet led to their closure."[6] They were closed and not reopened until trap experiments with the T'sou-ke First Nation began in this decade.

Reef Nets

A reef net is laid in the path of the fish, not unlike a trap, but is then lifted from the water by hand or other means as the fish enter the net. This is distinct from gillnetting in that the fish are not 'gilled' but are scooped up in the net.

A reef net will work well only in certain locations. Success of the net depends primarily on wind conditions, tides and the migratory behaviour of the stocks. Historically, reef net sites were often at the mouths of bays, where the net could be set so that the tidal flow out of the bay passed through the net. Traditionally, the location was not owned, but within a First Nation (such as the Salish) families would have rights to specific sites.

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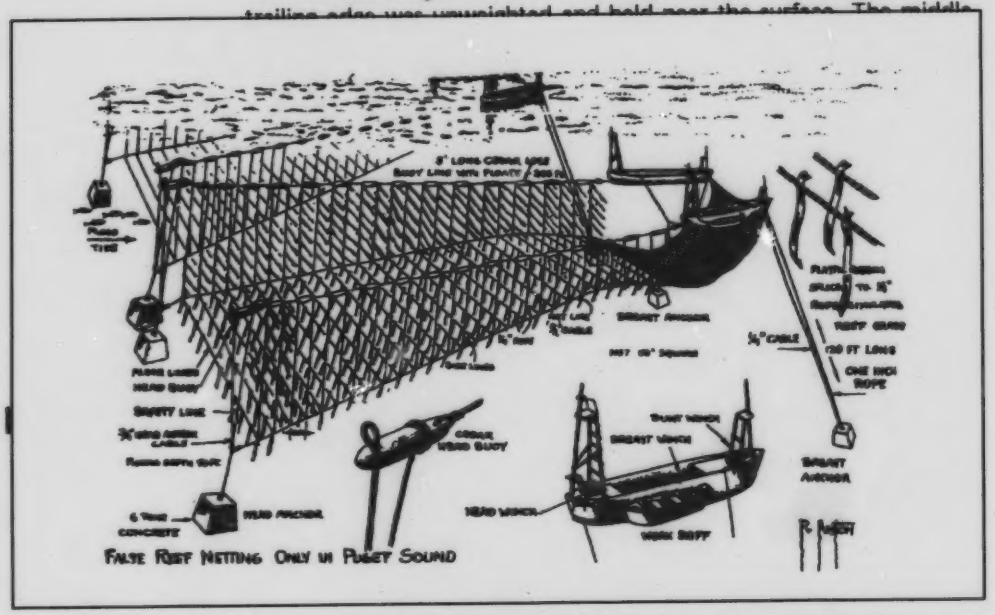
[5] Ward (1993).

[6] Curry (1998a).

Original reef nets would have been made of cedar rope and willow bark, with anchors and net weights made of stone, and buoys fashioned from cedar logs. Reef nets were suspended below the waterline between two large canoes. In each canoe, fishermen would hold the net in place with lines attached to the sides and corners of the net. The lead edge of the net was weighted and allowed to sink; the



A drawing of a typical contemporary Puget Sound reef net operation. Art work by R. Aiston.

[7] Curry (1998a) and Claxton and Elliott (1994).

A fish wheel consists of a series of baskets mounted on a wheel. The wheel is suspended on an axle over a river at the height that permits the water flow to catch the baskets and turn the wheel. The foundation for this structure may be a set of piles or, more commonly, a floating platform anchored in a suitable spot in a river. As the fish swim upstream, they encounter a series of leads that direct them towards the fish wheel. When the fish swim under the wheel, the baskets sweep through the water and scoop them up into a collection box where they can be sorted, harvested or released. As with other historic selective technologies, the success of a fish wheel is highly dependent on its site and operators. Site factors include water speed and depth, as well as water clarity. Water speed affects the revolution speed of the wheel, depth must be maintained so that the wheel has room to turn in the water, and too-clear water is undesirable since the fish can see the wheel.

A contemporary photograph of the Yale Fish Wheel. Photo Karl English.

In North America, fish wheels were used as early as the 1820's in the east coast shad fishery. On the west coast, they appeared first on the Columbia River, then in First Nations fisheries in both the Yukon Territories and Alaska. The commercial use of wheels was abolished in Washington in 1934, although at their peak wheels in 76 locations harvested over 5% of the catch. This experience confirms the importance of site, in that fish wheels from this time caught at

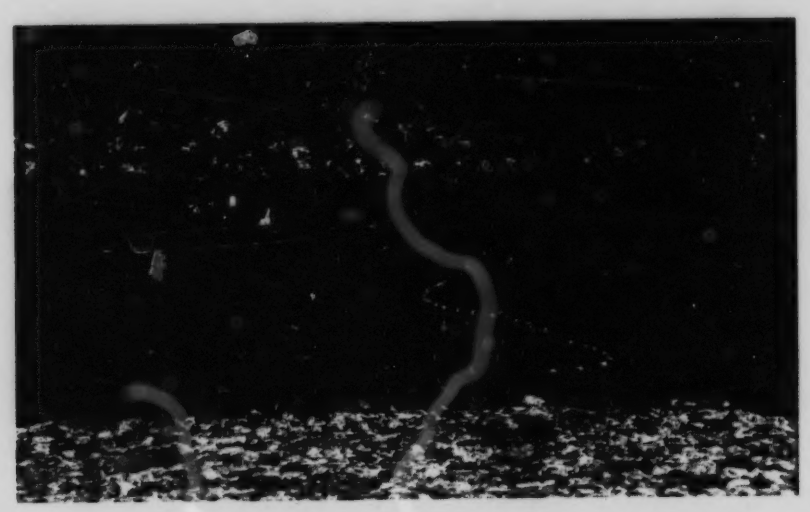
widely different rates depending on where they were located. Different species also lend themselves to harvest with different kinds of wheels, as they typically migrate upstream at different depths.

There are still fish wheels in operation in Alaska and BC, and 1998 saw the beginning of a range of new fish wheel experiments. These cases are discussed further below.

Beach Seines

Seining is one of the most common fishing techniques in the world. In general, seine nets encircle the fish, are pursed or otherwise closed at the bottom so the fish cannot escape, and are then emptied by some means, by lifting the entire seine net out of the water,

A beach seine being set. Photo DFO Communications.



or by brailing or dip netting, which involves emptying the larger seine net with a smaller one.

A beach seine is a modification of the prevalent commercial practice of purse seining and is typically used in river settings. Operators work from the beach with the help of a boat, which lays the net, typically in a semi-circle leading away from the beach, downstream for some distance, and then back to shore. When the beach seine

net is fixed at both ends to shore, it is drawn in along the bottom instead of being pursed like conventional seine gear. As the net is pulled towards the beach, the fish are captured in a smaller and smaller enclosure from which they may be then dip netted, sorted and released live or harvested.

Historically speaking, beach seining was somewhat less common among BC First Nations than other fishing methods. It is being extensively experimented with at present, however, and these operations are dealt with in more detail below.

Dip Nets

A dip net operation is mounted from the shore or a suspended platform with a small net at the end of a long pole. The fish are removed from the water as they pass, one by one. Among First Nations, dip netting was a very common harvest method for many years, particularly on the Fraser River system.[8] Dip netting can be highly selective with regards to the species and run harvested, as the fish are removed from the water one at a time, and may be released relatively quickly.

New Attention to Selectivity: Experimentation from 1995 to 1997

In both the north and south, fisheries managers and fishermen have been experimenting—independently and in co-operation—with ways to make fishing more selective. This has been going on at least since the mid-eighties. Over these years, significant work has been done by DFO managers to time and situate openings so as to avoid weaker non-target stocks, and time and area closures remain a substantial part of the selectivity effort to this day. Fishermen meanwhile, have long been trying various ways to improve the selectivity of their gear.

The motive to improve selectivity over these years has always been to avoid capturing, or decrease the mortality of, non-target species,

[8] Bennett (1973).

although the species in concern has changed with the times and in different locations on the coast. In the north, for example, steelhead were the primary concern during the early to mid nineties, where coho has become a more dominant concern of late. In this section we provide an overview of this history of experimentation, with a significant focus on the past 3-4 years.

Experiments with Existing Gear

Gillnet Modifications

Gillnet selectivity experiments have been carried out on the north and south coasts since the 1980s. Tests have involved the use of different numbers of strands, mesh sizes, hang ratios, weed lines, as well as various kinds of tooth and tangle nets.

Some Two definitions are helpful before we begin this discussion. Gillnet webbing consists of a number of strands twisted together. Traditionally, a 30 strand net was the standard and monofilament net, consisting of a single strand, was banned because its extremely low visibility to fish in the water made it too effective for fishing salmon. Monofilament net caught target and non-target species very effectively and caused significant mortalities of seabirds. A recent innovation is a 6 strand net known as Alaska Twist. This net is less visible than the old standard 30 strand net, but more visible than monofilament net. Alaska Twist nets are much stiffer and bulkier than standard nets, which is thought to contribute to their effectiveness at fishing selectively.

A tangle net is a net configuration designed to capture fish not by gilling them but by entangling them in the net. A tooth net is a tangle net that utilizes, in addition, smaller mesh sizes so that fish are tangled by their teeth. Both these innovations contribute to the improved selectivity of these types of gillnets.

A weedline suspends a gillnet some distance below the surface (or corkline). This allows species migrating at a shallow depth to pass over the gillnet without being tangled or gilled.

Weedline experimentation was the result of data gathered in the late eighties in Fisher and Dean Channel. There, tagged steelhead were

found to swim consistently within 1.5 metres of the surface[9]. Weedlines were subsequently tested to assess their potential for the Skeena system. In the river section of Area 4, weedlines were not found to produce a significant enough decrease in steelhead catch to be practical. In the marine section of Area 4, 120 cm weedlines resulted in a significant 76% reduction in steelhead catch, but the accompanying 29% decline in sockeye catches was thought too large to justify the change.[10]

Several improvements were considered to improve the catchability of the net without removing the potentially positive effect of the weedline. In 1992, comparison testing was carried out with weedline nets using traditional webbing and weedline nets using the more efficient monofilament webbing. Test results suggested that the most effective net type was a 60 mesh monofilament net with a 120 cm weedline. It reduced steelhead catches by 69% because of the weedline, while increasing sockeye and pink catches by 17% and 92% respectively due to the monofilament.[11] These results notwithstanding, the monofilament net was subsequently banned due to concerns about the overall catchability of the net and the impact the net may have on sea birds. Some dispute still surrounds this decision in certain areas.

In part as a result of this experience, testing of "Alaska Twist" nets were carried out on the Skeena in both 1996 and 1997. In the 1996 "Skeena Selective Gillnet Study", one conclusion was that the Alaska Twist 90 mesh net using a 1.2 metre weedline did provide a high sockeye catch while reducing steelhead catch. This led to the approval of the net, and the establishment of a 1997 observer program to confirm the results of the study.[12] For the experiment, observers boarded packers during seven different gillnet openings to gather information in interviews with fishermen. The informal methodology did not provide as much detail as the 1996 study. Still, the study concludes that "the Alaska Twist nets catch a dramatically greater proportionate number of coho with respect to sockeye than

[9] Western Renewable Resources (1992).

[10] Western Renewable Resources (1992), p. 2.

[11] DFO (1998f).

[12] JO Thomas & Associates (1997d).

do the standard nets."[13] Relative steelhead catches were difficult to quantify given very low encounters. It has been subsequently suggested that timing closures, especially night-time closures, might reduce this coho interception.

Formal testing of tooth nets in the Fraser system began in 1995 and 1996.[14] Both years, a small mesh net was used to target chum salmon. In 1996, tests were carried out near Annacis Island with a 3½ inch mesh, 3:1 hang ratio, 120 mesh depth and 100 fathom length. The vessel's main hold was used for the target chum species (kept in slush ice) while the side tank was used for non-target species. The net was set off the drum in an S-pattern to create loose bags in the net that might facilitate entanglement, and the soak time was set at 20 minutes to minimise the time tangled fish would spend in the net. As the net was brought aboard after a set, non-target species were released directly from the net back into the river if they were still vigorous and healthy. If they were sluggish or showed wounds, they were held in the side tanks for observation.

Results of the 1996 Fraser River study suggested that the tooth net had promise as a selective fishing technology for the commercial fishery. Of the coho, chinook and steelhead intercepted, 88%, 98% and 100% respectively were released live, although the study noted that a second person should be aboard in commercial fisheries using tooth nets to ensure proper handling of non-target fish. The net was recommended for further testing and research.[15] The operator of the modified gillnet commented in his own progress report that the net's performance "exceeded my initial hopes," and that it was quite easy to handle chums caught in the net in such a way that a high quality product was ensured.[16]

During the 1997 chum season, two more gillnet studies were completed on the Fraser River. In the Modified Gillnet Study,[17] three boats fished different parts of river below Maple Ridge with special nets consisting of a 'control' half and a 'test' half. The test half had

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[13] JO Thomas & Associates (1997d), p. 7.

[14] JO Thomas & Associates (1997a).

[15] JO Thomas & Associates (1997a).

[16] Petrunia (1997a).

[17] JO Thomas & Associates (1998a).

an upper panel of a larger mesh size, intended to reduce non-target encounter rates. The lower half of the test half, and the entire control half of the net, had smaller mesh size and a looser hang ratio. The objective of the test was to limit by-catch of chinook, coho and steelhead during chum fisheries. The test concluded that the proportion of by-catch in the modified half of the experimental net was no lower than in the control half of the net. However, the test also revealed that capture of steelhead was more prevalent in the top portion of the net, indicating that this species is harvested at a shallower depth. The test also indicated that steelhead survival rates were much higher than coho. Recommendations were tabled to continue testing and modifying the net, for example, by making the mesh of the upper portion still larger to further reduce steelhead and other non-target interceptions.

Also on the Fraser in 1997, there were continued tests made of the tooth net.[18] The net from the 1996 experiment was slightly modified for re-testing, by incorporating a 50 fathom test section consisting of 17 inch mesh from the corkline 14 meshes down to 3½ inch mesh hanging for another 50 meshes. The other 50 fathoms of net consisted of the same 3½ inch mesh as the year before. The vessel used the same live tank configuration and laid the net in the slack "S" pattern as the year before.

The results of the test were that catch of all species was reduced in the modified half of the gillnet. Catch reductions were: 36.3% in chum, 57.9% in coho, 61.5% in chinook, 88.9% in pink, 83.3% in sockeye and 100% in steelhead (although the sample size for pink, sockeye and steelhead were very small). Of the coho and chinook intercepted, 89% and 96% were released alive, although seal predation was estimated to account for almost half the coho mortalities. The capacity of the live holding tanks limited the number of fish held to 12 or 15 fish, and so all robust non-target fish were released directly from the net back into the river. Based on these results, the report of this study recommended that testing be continued, particularly that the impact of multiple capture and set times be assessed.

[18] JO Thomas & Associates (1998b).

Seine Modifications

In the past few years, there have been various projects undertaken to test and improve the selectivity of the seine fleet. These tests have involved seine bunt modifications (selectivity grids to permit the escape of juveniles and knotless webbing to minimise scaling), as well as the comparison of different handling practices such as ramping, brailing, on-deck sorting, survival or recovery boxes, and release techniques.

Although our discussion concentrates on the past 3-4 years, this experimentation actually began in the late eighties with sorting experiments carried out in Area 4. These early efforts were among the first to see if sorting catch on-deck would allow the selective harvest of pinks, sockeye and chum without killing non-target species such as chinook, coho and steelhead. These tests did not incorporate long term mortality studies (neither net pen observation nor tagging were used), and observers were only able to assess the immediate health of fish as they were released.

In 1995, however, formal testing was begun to assess mortality rates. These "Special Seine Fisheries" were carried out at the mouth of the Skeena River, and were mounted in part to enhance the catch of Skeena River sockeye and pink by seine vessels without impacting coho, chinook and steelhead. In 1995, nine such fisheries were carried out between July 28 and August 23. Vessels were required to hail into the fishery empty, use recovery boxes (sometimes called live boxes, or blue boxes), unload all sets by brail, allow independent observers, and hail out of the fishery to the DFO patrol vessel in the area.

Observers examined 351 sets made during the test period. Sets were brailed and then sorted on deck in various compartments. Non-target fish showing signs of trauma were held in the blue boxes until recovery or death. Other restricted species were released directly overboard. Results of the study suggested that, while chinook, chum and steelhead indicated no immediate health problems, coho more often showed signs of trauma and the recommendation was made that mortality studies be carried out. The study also raised various concerns about handling practices and recommended education on handling and species identification for seine crews.

In 1996, mortality testing was completed in the Skeena River region (statistical areas three, four and five).[19] The objective of the Seine Release Mortality Study was to "quantify the short term survival of these [non-targeted] fish as well as to compare it with the survival success of fish that were collected from other conventional seine fisheries in the area." To do this, samples were taken from various sets during the Special Seine Fishery in area four, as well as from seine charters and conventional seine fisheries in areas three and four. These fish were transported to a separate vessel for tagging and 48 hours of observation. Survivors were then released back into the areas from which they had been harvested.

Results indicated mortality rates of 5.9%, 45% and 3.8% for coho, chinook and steelhead respectively (although the sample size for chinook was small). The study also concluded that "...mortality is proportionally greater for fish having been ramped rather than brailed. The overall mortality for all species of ramped fish is 17.3% and 4.5% for brailed fish." The study notes that this effect is most noticeable with sets of over 500 pieces. The study ultimately concludes that there is a high survival rate for brailed seine-caught salmon, and recommended that brailing be continued. The study noted again that education is needed on release methods, blue box usage and other handling issues.

In 1997, mortality testing continued in the Skeena area seine fishery.[20] The 1997 study focused on coho caught under 'normal' fishing conditions. Eight vessels participated in the study, each with an observer evaluating mortality rates for seine-caught coho in areas one, three, four and five. A covered tote holding 12-15 fish in circulating water was used as a live tank. 450 sets were observed in all. 496 coho were caught. 400 were tagged and held onboard for observation and of these, 19.8% died during 6 hours of observation. Overall mortality was estimated at 23%, contrasting negatively with estimates from the 1996 study (5.9% mortality). Primary causes of mortality were identified as crushing and scale loss. The report on the study recommended that longer term mortality testing be carried out and that multiple recapture impacts be explored in both conventional and special area 4 seine fisheries.

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[19] JO Thomas & Associates (1997b).

[20] JO Thomas & Associates (1997e).

Also in 1997, tests were carried out in the Queen Charlotte Islands (area one) to determine chinook encounters rates.[21] 44 sets from 29 boats were observed over five fishing days, mostly beach sets around Langara Island at Coho Point. The observer noted catch of all incidental species: coho, chinook, steelhead as well as cucumbers, octopus, rockfish, herring, eels and birds. Non-target species were blue boxed before release. Observers noted that it was not always advantageous to release immediately, as fish might well end up in the next set, be counted more than once, and sustain additional damage in recapture.

Seine data was also gathered in 1997 from the area four special fishery. Building on the results of previous studies, guidelines were introduced to increase selectivity in the fishery. Observers were mandatory. Boats had to enter and leave the fishery empty, and hail a designated Fishery Patrol Vessel upon doing either. All sets had to be brailed and sorted before putting any fish in the hold. All species but sockeye and pink had to be returned to the water.

Results of the study were mixed. Overall, 88.6% of non-target fish were released back into the ocean in good health. In the words of the Summary Report: "These numbers indicate a successful fishery in spite of the fact that the fishery was closed due to non-compliance."[22] The report also notes that success in seine selectivity will depend on fishermen consistently brailing and sorting catches. Jellyfish coming onboard during this process caused problems that might be rectified with special protective clothing for crew members.

Troll Modifications

Trollers have had various measures imposed over the years—gear modifications and management techniques—designed to address concerns about interceptions of weaker stocks. As far back as 1985, hook barbs were crimped and fishing restricted to beyond the 50 fathom depth to address chinook conservation concerns. In 1996, non-retention of chinook was used in certain areas, and the crimping of hook barbs was again made mandatory.[23] The Chinook Technical Committee of the Pacific Salmon Commission has also researched

[21] JO Thomas & Associates (1997f).

[22] JO Thomas & Associates (1997c), p. 2.

[23] T. Buck Suzuki Environmental Foundation (1997).

commercial troll mortality rates for chinook salmon caught with barbed and barbless hooks. The CTC determined that legal barbed hooks had a 21.1% mortality rate associated with them, as opposed to 18.5% for legal barbless.[24]

Experiments with Alternative Gear

Fishwheels, traps, beach seines and other "new" gears have proliferated in the Skeena and Fraser systems in recent years in direct response to conservation concerns about steelhead and coho. It is estimated that 200,000 sockeye were taken by aboriginal fishermen using these selective methods in 1997.[25] Given the range of these experiments—in location, in size and in degree of success—a comprehensive description of every one is all but impossible. In this section, however, we offer an overview of experience with some of the key technologies.

Fish Traps

There has been a number of small scale weir-style traps used in various locations around the province. The Nlaka'pamux have experimented with them in the Nicola River and the Shuswap Nation has several coho counting fences. Perhaps the largest trap experiment, however, has been carried out by the T'sou-ke Nation in their traditional fish-trap location off Muir Point in the entrance to Sooke Bay.[26]

The T'sou-ke trap project was the culmination of extensive research and consultation with other groups using fish traps. The proposal, which originated with the T'sou-ke Nation, received support from DFO officials responsible for implementing the Aboriginal Fisheries Strategy. The proposal had been built on archival research, specifically a review of historic trap design at Sooke, and the interviewing of elders familiar with the T'sou-ke reef nets and fish traps of history. A trap net workshop was then arranged, providing the opportunity to review trap technologies from other parts of the world.

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[24] T. Buck Suzuki Environmental Foundation (1997), p. 28.

[25] Orr (undated).

[26] T'sou-ke Nation (1997).

During the 1995 salmon season, field work began using a small prototype trap-net modelled on a Newfoundland cod trap fishing near Petty Harbour, NFLD. The trap consisted of a 60 fathom lead net with 8 inch mesh that guided passing fish towards a small opening in a single suspended chamber (the spiller). The lead and spiller were anchored to the ocean floor in 8 fathoms of water with Danforth anchors and a number of 850 pound train wheels. The trap was tended by a 26 foot modified herring skiff and a 12 foot aluminium skiff. The trap could be loaded entirely into the herring skiff, and could be taken to an adjacent beach for maintenance or repairs.

During eight fishing days in 1995, the prototype trap caught 42 fish: 6 sockeye, 25 coho, 8 pink, and 3 chinook. The trap's selectivity was hampered by the arrival of marine mammals, particularly California sea lions, which were observed entering the trap. After their arrival, only the heads and tails of salmon were found in the trap.

A full-scale trap was implemented in time for the 1996 salmon season. The design of this trap represented the synthesis of work done in 1995, further consultation with elders and others, testing of the model in the flume tank at Memorial University and other technical work such as the preparation of plans. A multi-chambered trap was installed off Muir point at the east entrance to Sooke Bay at nine fathoms depth. The trap had a 120 fathom lead net of 3¾ inch mesh, which extended from the body of the trap to the edge of a kelp bed. The body and lead were suspended from lines anchored in place with anchors and train wheels as in the pilot. The trap was marked on the surface with navigational buoys and with flashing amber lights.

The full-scale trap was operational by August 12th and was fished until September 12th. The net caught 383 salmon before August 24th. 211 of these were kept, while 172 were released (128 tagged). No fish were caught after this date because the trap had been installed just after the peak of sockeye migration. Marine mammals were again a significant concern in the area, and 2 seals and 6 sea lions were shot. These marine mammals were not used for food but the hides and other parts were used by the T'sou-ke First Nation.

The trap was modified and tested further from May to August 1997. Goals for the year were to improve the anchoring system,

test the trap during heavier sockeye returns, and improve fish handling and selective harvest system. The new anchoring system consisted of 65,000 pounds of anchors, chains and train wheels. It secured the trap effectively, although requiring 50 dives to install and remove. The trap was fishing by July 12 and large volumes sockeye entered the net the following day. Weather conditions did not permit emptying the trap for several days however, at which point all the fish were harvested due to the continued bad weather and the lack of a selective harvest pen, which could not be built due to lack of funds. The trap fished through to August 25th, by which time a total of 2495 salmon had been caught (2463 sockeye, 2 pink, 26 chinook and 4 steelhead. 25,000 pounds of mackerel were also caught in late August). Underwater cameras in place at the site during this period recorded large numbers of salmon leaving the outer chambers of the trap. But this lower than expected catch is also attributable to the arrival of sea lions in mid-August and to high salmon diversion rates in 1997. (In years of high salmon diversion to the inside passage a smaller proportion of salmon migrate down the west coast of Vancouver Island and, therefore, fewer salmon pass the T'sou-ke nation fishing site.)

In 1998 the T'sou-ke trap net was fished again near Muir Point, but no fishery was permitted on the Early Stuart stock, the stocks that are believed to migrate close to the shore at Muir Point. Other factors such as warm water and modifications to the design of the trap resulted in very little catch (3 salmon in the trap and 5 salmon gilled in the lead). In 1998, the T'sou-ke Nation were also involved in an experiment to move this trap into the Fraser system. Results of this and other 1998 trap experiments are discussed below.

There have been other trap experiments in the province over the past 5 years, including a collaborative effort between the Sumas Nation, the UBC Mechanical Engineering Department, and the Ministry of Environment, Lands and Parks. This consortium tried a trap for live steelhead capture in 1996. The trap had three components: a lead, an entrance chamber and a spiller. Given that net leads often collect debris and are difficult to maintain, the group used a system of bright ribbons to direct the salmon towards the first chamber. The entrance chamber was diamond shaped measuring approximately ten metres by four metres, the spiller was a rectangular box approximately 1 by 2½ metres, stiffened with a frame of aluminium pipe.

In the end, this trap did not catch steelhead as designed. The trap caught only sturgeon, whitefish and some early run spring salmon. Steelhead introduced to the trap artificially, moreover, were able to escape. Seal predation was also an ongoing problem. The trap was eventually damaged by rains and floating debris.

Fish Wheels

There have been numerous significant fish wheel operations spring up in BC over the past 5 years. These include work done by the Skeena Fisheries Commission at Kitselas, as well as by the Nisga'a, Gitska'an Wetsuete'en, Stolo, Skway, Yale, Lheidi'T'enneh, and Sumas Nations. In 1998, still other wheel locations and designs were tested, although these are discussed further in the next section.

The Kitselas fishwheel in Kitselas Canyon has been in operation for 5 years, working in conjunction with the UBC Department of Engineering. It was originally established for use in steelhead live-tagging and as an experiment to test the viability of the wheel in harvesting for ESSR fisheries. The Kitselas have operated up to 4 wheels in a season, originally using a design with three wooden baskets, aluminium pontoons and live boxes. In 1996, the wheels were modified with aluminium baskets, which are smaller and stronger and were found to cause breakdowns less frequently. Experimentation continues with live box sizes and configurations.

Overall, the Kitselas wheels as they are presently designed are considered successful as a pilot sales harvest technique at smaller volumes.[27] The Kitselas Canyon location is considered critical to this success, providing water depth and water flow that keep the wheels turning at the optimal 3 rpm. On average, these canyon wheels have been able to selectively harvest from 5-10 thousand pieces each in a season.

The Gitska'an fishwheel in the Babine River has had similar success. The wheel has been running for 2-3 years and is considered successful in harvesting selectively. The Gitska'an fishwheel is situated in a region where river current is strong. Leads are difficult to deploy under these conditions, and so the Gitska'an wheel uses a rigid frame which holds the netting material of the lead in place. In a progress

[27] Mikkelsen (1998).

report written in January 1997, Jon Mikkelsen of the Department of Engineering at UBC says: "Considering that the entire design, construction and installation was achieved within a short time frame at a remote location, the lead performed remarkably well."[28] Harvest was not possible at the Babine wheel in 1998 due to abundance issues.

In the Fraser system, there have been experiments with the Skway Nation near Chilliwack over this same time period. The Chilliwack wheel targeted chum and was considered selective at relatively low volumes. Also in the Fraser, there is a Lheit Lit'en fish wheel in Stone Creek.[29] This twelve foot wheel, the first of its kind in the Fraser system, operates in an area of the Fraser where there are considerable chinook conservation concerns.

The Nisga'a have carried out some of the most extensive experimentation with fishwheels in BC. Since 1992, the Nisga'a First Nation have worked to test and modify wheel and site configurations to evaluate the viability of these as tools in stock assessment for the Nass system.

Testing has centred on two areas, near Gitwinksihlkw and near Grease Harbour. The Gitwinksihlkw wheels have focussed on tagging, index fishing and biosampling, while the Grease Harbour wheels have been used for tag recapture, ESSR harvesting and biosampling.[30]

In 1993 there were three fishwheels tested, capturing 16,458 fish total: 10,963 sockeye, 3,944 pink, 919 chinook, 466 coho, 99 chum and 67 steelhead.[31] The wheels were judged to catch sufficient numbers to be used as a stock assessment tool, with more than 2300 fish being sampled for sex, length and age. According to LGL Limited's report on the 1993 experiment: "Sufficient numbers of chinook and steelhead were captured for a large scale radio-tagging project that the results were used to estimate the distribution, timing and abundance of chinook and steelhead in the Nass watershed."[32]

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[28] Mikkelsen (1997a).

[29] DFO (1998n).

[30] Nyce (1998).

[31] Link and English (1994).

[32] Link and English (1994), p.2.

Population estimates were not as accurate as expected due to a number of difficulties. Various recommendations were made for changes in upcoming years to identify and eliminate sources of error.

Operationally, the 1993 fish wheel design was considered superior to the design used the year before. Aluminium baskets and pontoons provided better strength and the ability to raise the baskets and live boxes out of the water resulted in fewer breakdowns, lower staffing costs, and more complete data collection. Larger recovery boxes allowed for less frequent sampling and tagging sessions. Finally, the three basket design mounted on a nine spoke wheel required considerably less water pressure to turn, allowing it to be placed in more protected areas.

Four Nisga'a fishwheels were tested in 1995. Two of them had been constructed in 1993 and were operating near Gitwinksihlkw. One other fishwheel had been constructed in 1994 and was operating upstream of Grease Harbour. The final wheel was constructed in 1995 and also fished upstream of Grease Harbour. The four wheels operated for 6,762 hours, catching 34,642 salmon: 22,408 sockeye, 8,881 pink, 1,987 coho, 1,031 chinook, 224 chum and 111 steelhead.[33] An evaluation of fish wheel performance as a stock assessment tool on the Nass system concluded that the variability of catchability of the four wheels was less than the variability of catchability of the conventional Monkley Dump test fishery, indicating that the wheels might develop in time to be a more reliable test mechanism than the conventional test fishery.[34] Overtime, in fact, the Nass wheels have moved past being strictly technology experiments and are now an ongoing part of the stock assessment process on the Nass System.

Fish Wheel Design and Selectivity Issues:

The experiments in BC during this time have tended to make use of one of two basic designs. The first is a descendent of the wheels used by First Nations in Alaska and the Yukon. This model typically has aluminium pontoons, wooden baskets and a steel axle. The second design is a modification of the first. It was developed during fish wheel experiments carried out by the Nisga'a Nation on the Nass

[33] Link and Gurak (1997).

[34] Link and Gurak (1997), p. 16.

River, and was inspired in part by the design of fish wheels on the Columbia River system many years ago. There were various adjustments made to derive this second basic model, but essentially it is of all-aluminium construction and has a larger holding pen.[35] The newer revised models of fishwheels are estimated to cost between 20 and 40 thousand dollars to build.

The impact of fishwheel designs on selectivity is difficult to quantify, but there is some agreement that the size and construction of the live box design is an important factor. Since 24 hour staffing is not often feasible, the live box must be large enough to safely accommodate all the fish harvested between the departure and arrival of staff between shifts. Release technique is also important.

Site specific factors are also very important. The ideal location must have sufficient current to turn the wheel at 1-4 rpm, the water cannot be too clear or the fish will see and avoid the wheel, and the water must maintain a working depth. Also, since weirs and leads guiding the fish into the wheel are very difficult to maintain in river conditions (they clog with debris quickly), the natural structure of the shoreline must be conducive to guiding the fish towards the baskets. Canyons have typically been the best locations to date.

Possible Future Fish Wheel Developments:

There are various improvements to fish wheel design that are being actively considered. Power systems might provide a means of turning the heavy wheel through the water even in the absence of strong currents. Free of the requirement that they be situated in sites with strong current, powered wheels might open up estuary locations to fishwheel harvest. It is anticipated that powered models will be tested as early as next year.

Experimentation with different kinds of weirs and leads is also likely in the near future. A net lead of 16 inch mesh has been considered but not yet tested. This net would be too large to actually snare the fish by the gills, but it is thought that the fish may instinctively avoid contact with the net, and be guided by it towards the wheel.

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[35] Link and English (1994).

Other Alternate Gears

Members of the Katzie First Nation joined up with the Fraser River Fisherman's Society (FRFS) to test a beach seine as early as 1996.[36] The test was conducted with a modified seine net to fish in the shallow waters of the river to see if releases would be in better condition than gillnet releases. They had an allocation of 10,000 chum. All other species had to be released.

The test was carried out at Derby Reach near Langley, part of the Katzie First Nation traditional territory. The site could have been anywhere in Katzie territory, but the Derby Reach location was chosen because the river bottom is relatively flat and there is a large beach area where the net can be pulled toward shore and the fish sorted and released or harvested. There are also several large trees that can be used to secure the beach lines for the net and vessels.

Besides the modified seine net, the hardware required for the Katzie/FRFS beach seine was a main vessel, a superpunt, which laid the net without a drum and retrieved with a power block. An additional herring punt was used as a support vessel and a number of other smaller vessels were required to ferry crew. Staff was a minimum of eight to ten people. To set the net, it was secured to the beach, run downstream by the superpunt, then left to set for 15 minutes to an hour. The net was then 'closed' by pulling it in a semicircle back to shore. When the vessel was secured to the beach, the power block could then be used to pull in the net. Non-target species were released, and target species were typically loaded into the superpunt. A full set, including closing the seine and harvesting, took about half an hour.

Results in 1996 were mixed. The fish seemed in overall good health, but sluggish. Chum harvests were also low and debris moving through the fishing zone caused snags and tears. Tide and daylight conditions must be co-ordinated for the beach seine to work, and the limited time this left to harvest was problematic. In 1996, 100 fish per set was the maximum encountered. Night time fishing might have improved this, but safety on the river at night was an issue. A report written on the 1996 testing recommended that the sluggish

[36] JO Thomas & Associates (1997a).

fish released be held and mortality studies done to be sure they survive.[37]

The Katzie/FRFS experiment was continued in 1997 with some similar difficulties and a poor chum return. The tide conditions were critical, limiting operations to just a few hours a day. The boat was changed and a drum was used for hauling the net (instead of a block). A lighter net was also tried as an experiment, but it was still prone to snags. Testing of the Katzie beach seine continued in 1998.

Beach seine experiments have also been carried out in the Skeena system. The Gitksa'an Wetsueten'en Watershed Authority operates several very successful beach seines between Fiddler Creek near Terrace and the confluence of the Skeena and Babine Rivers. These seines captured over 120 thousand sockeye in 1996, with a peak weekly catch of 38 thousand. This fish is sold under a pilot sales agreement. Below Terrace, the Tsimshian Nation has also fished beach seines catching smaller numbers in both 1995 and 1996.[38] In general, however, it is thought that river characteristics above Terrace are more conducive to beach seine operations.

Other successful beach seine experiments have been carried out on the Pinkut and Fulton River stocks at Babine Lake. In 1996 a beach seine and a small boat-based seine were used to harvest excess spawners from these two systems. Over 200 thousand sockeye were taken from the Fulton, and over 60 thousand from the Pinkut. The harvest was partly allotted as food fish, partly sold under a pilot sales agreement. The proceeds from the latter were distributed between a consortium of Skeena bands and the Skeena Watershed Committee.[39] As with fishwheels and other alternative gears, the selectivity of beach seines is highly site specific. The beach seine does not work well across an uneven bottom, as this will cause snags. It is better suited than the fishwheel to slower moving waters and to shallow, sandy bottomed river bank locations.

Dip netting is another alternative technology that has historical roots in BC and is, increasingly, being used today. Provided those using

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[37] JO Thomas & Associates (1997a).

[38] T. Buck Suzuki Environmental Foundation (1997).

[39] T. Buck Suzuki Environmental Foundation (1997), p. 6.

the dip net can differentiate between salmon species, the technique is highly selective because fish are generally removed one by one from passing river waters and can be released very quickly. Dip netting may immediately be associated with smaller scale First Nations food, social and ceremonial fisheries, but significant volumes have been taken in some years. In the Gitsegas Canyon, 14,000 pieces have been taken in just a two-week period. At the Morristown Canyon fish ladder, the Gitska'an Wetsueten'en used dip nets in 1996 to harvest over 100,000 pieces, mainly pinks, in just a 7 day period. Dip netting has also been used by the Babine Lake Nation at the Babine fence, a DFO operated counting facility.

Reef netting has seen a resurgence in recent years, primarily in the State of Washington. The Lumme Indian Band, as well as up to 40 commercial fishing operations, have been involved in this selective fishing technique in the past five years.[40] The technique, as it is presently practiced, involves setting a 50' by 50' net between two pontoon boat at flood tide. Fish are guided into this net by a 200 foot long lead. This lead takes the form of a three sided funnel, open to the surface, with a closed bottom and sides. It is suspended from the corkline with cedar log floats and anchored to the bottom a six-ton concrete anchor at each of four corners. The lead mesh consists of plastic ribbons spliced to ¼" rope, simulating weed grass.

When the fish have followed the lead into the reef net, it can be pulled towards the surface to form a holding pen. Working from the two pontoon boats, crews of two or three fishermen use dip nets to remove non-target species. The non-target fish are not taken into the dip net fully, but guided towards an escape hole just 6 inches above the water line. Since the fish are not removed from the water and handled, and not taken completely into the dip net, this technique is thought to minimise the trauma and scaling inflicted on non-target species.

[40] Pravenshek, L. (1998).

Selective Fishing in 1998

The Selective Fisheries Program

Before our discussion of selective fishing experiments carried out in 1998, we offer a quick summary of the events leading up to the 1998 fishing season.

- the Kelleher Process of early 1998;
- the report of the Coho Response Team in May 1998;
- the establishment of DFO's Selective Fisheries Program.

Stephen Kelleher was asked on October 15, 1997 to continue his work with BC commercial salmon fishery stakeholders in an effort to reach consensus on the development of an allocation plan. The Minister instructed Mr. Kelleher to seek consensus but to recommend a reasonable plan in the event there was no consensus. Beginning his work in early 1998, Mr. Kelleher solicited extensive input from stakeholders across a range of issues relevant to allocation. One of these areas was selective fisheries, specifically, how new selective fisheries should be accounted for in an allocation process. Mr. Kelleher made a number of comments and recommendations on this issue, including the following:

> *In the interests of encouraging commercial license holders to innovate, and providing them with an opportunity to catch their allocation in new more selective ways, I recommend that the Department establish a program to consider applications from commercial license holders to harvest by more selective means on a trial basis.*[41]

Coincidental to this, there was a rising awareness of conservation problems facing BC wild coho stocks. The Pacific Stock Assessment Review Committee advised that "...Thompson Coho aggregates are extremely depressed, will continue to decline in the absence of any fishing mortality under current marine survival conditions, and that some individual spawning populations are at high risk of biological

[41] Kelleher (1998), p. 62.

extinction."[42] The Pacific Region Coho Response Team, meanwhile, was considering "Selective Fisheries Approaches". Their findings were released in May 1998, providing options to management and recommendations for action during the 1998 season.

On May 21, the first of two key ministerial announcements was made. The Minister announced the Department's intention to rebuild and protect BC coho salmon stocks. This would be accomplished through various means including the imposition of a zero mortality target the threatened Thompson and upper Skeena stocks, and the establishment of a program to accept proposals for selective fisheries experiments designed to explore ways of reducing coho mortalities.

On June 19, there was a second, related, announcement. Ministers David Anderson and Pierre Pettigrew (Minister of Human Resources Development Canada) jointly announced management measures for the 1998 salmon fishery and federal funding of a comprehensive plan to rebuild the resource, restructure the fishery, and help people and communities adjust to the changing fishery. In this announcement the minister said: "Permanent change is necessary for the salmon fishery. We can no longer accept the status quo or continue to manage salmon from crisis to crisis. For the future of fish and fishermen, we must get ahead of the curve and shift to a conservation-based fishery."

With these announcements, the Department's Selective Fisheries Program was effectively inaugurated. The overall goal of the program was to ensure conservation objectives were met while allowing safe harvest of target stocks and species. To accomplish this, the program's central objective would be "to avoid, or release alive and unharmed non-target species of concern." There would be various components to the undertaking. New fishing and management practices would be introduced in 1998 in commercial, recreational and First Nations fisheries. And in addition to this, a number of experimental selective fishing pilot projects would be considered.

The following sections discuss the various parts of the DFO's Selective Fisheries Program in 1998. First, there is a summary of various mandatory measures introduced in the commercial, recreational and

[42] DFO (1998dd).

First Nations sectors in 1998. This is followed by a detailed review of a range of experimental projects undertaken in 1998.

Mandatory Measures Introduced in 1998

Commercial

For the seine, gillnet and troll fleets, total non-retention of coho came with new mandatory observer programs, onboard revival tanks, logbooks in certain areas, hail in procedures, and dockside monitoring programs. Also, "red zones" were established in which critical Thompson and upper Skeena coho are prevalent. In these zones, fishing plans targeted zero coho mortality. "Yellow zones" were also established where Upper Skeena and Thompson coho are found in lesser numbers. In these areas, coho were to be avoided and released when caught by commercial, sport and native fishermen.

There was also a range of new, fleet-specific mandatory practices introduced before the 1998 season. For seiners, there were new hot spot and timing closures, but perhaps the most significant change was the introduction of mandatory brailing. Hydraulic stern ramps have been used widely in recent years to assist taking seine catches on board. However, this practice, known as "ramping", has also been criticised for the damage that can be caused to the fish in the process as well as for the sorting difficulties that are presented when a large seine set is unloaded on deck at once. Brailing is intended to circumvent some of these problems. While the purse seine is held in the water at the stern of the vessel, a small knotless-mesh dip net is used to remove small amounts of catch to the deck for sorting. Each brailer load is sorted—removing all coho, spring and steelhead to the revival box—before the another brailer load of fish is brought on board. The practice is estimated to add 30 minutes or more to the average set time, but is thought to greatly contribute to the crew's ability to identify and release coho and other non-target species with a minimum of damage.

The gillnet fleet also had a range of new regulations designed to increase their selectivity. Set times were limited to 30 minutes maximum. Night time fishing was restricted in some areas. Hot spot and timing closures were imposed and overall fishing periods were reduced. Trollers were required to use barbless hooks, respond to hot

spot and timing closures, conduct test fisheries prior to conventional fisheries, and use plugs for any summer chinook fishery.

Recreational

For the recreational sector, various mandatory measures were introduced. There were extensive time and area closures to protect coho stocks in red zones and non-retention of coho was imposed in all areas. Co-operative monitoring programs were established, and barbless hooks were made mandatory. Creel surveys were used to collect catch and effort data via boat counts from aircraft, as well as from ramp or roving interviews. Logbooks kept by charter operators provided additional information.

First Nations

For First Nations fisheries, there were a number of key changes in 1998. In most cases, there was non-harvest of coho in First Nations fisheries, even those where coho had been taken traditionally. Traditional fishing patterns were also modified in order to avoid coho interceptions, and a range of tag and release programs were established to help assess coho stocks and the impact of new fishing patterns.

Perhaps the most significant change in First Nations fisheries in 1998, however, were the range of "new" fishing technologies tried on an experimental pilot basis (many of these techniques are, of course, historic techniques). In many cases, these are discussed in detail in the section below.

1998 Experimental Projects

A range of experimental fisheries were conducted in 1998, intended to expand the knowledge base on selective techniques and gear. This section describes experiments that were conducted and provides a summary of the results if these were available at the time of writing.

Identifying Selectivity Projects to Pursue

There were two kinds of experimental fisheries carried out during the 1998 season. Some were conducted by the DFO to gather specific kinds of information about selectivity. Others were the result of

submissions by fishermen seeking approval to test a range of selective techniques and gear. This process—a response to the recommendation made by Kelleher in his report to the Minister of Fisheries and Oceans—was open to all commercial and communal licence holders. The DFO was guided by a number of key principles in evaluating these proposals:

- there must be no windfall profit to the licence holder
- any allocation for the pilot must come from existing TAC
- pilots projects must be intensively monitored to ensure conservation objectives are met
- pilots projects must be evaluated following the season

TIER	CRITERIA
One	Conservation
Two	General Manageability
	Future Applicability
	Additional Benefits
	Project Design
Three	Support Required

In the months before the 1998 season, over 90 such proposals were received, and DFO worked with provincial Ministry of Fisheries staff to evaluate and rank the proposals. The evaluation criteria were determined by a multi-stakeholder group in a July workshop. The evaluation criteria used in ranking the proposals are shown in the table on the left.

Conservation objectives were the first priority and the most heavily weighted criteria. In considering whether a proposal met conservation objectives, the workgroup posed a range of questions. Does the proposal avoid non-target species? Does it provide for the live release of non-target fish? To what extent does the method reduce post-release mortality, or support the assessment of non-target mortalities?

Four tier-two criteria were then assessed. The general manageability of the proposal was evaluated in terms of how easily the pilot project might be monitored and catch levels verified. Future applicability was defined as the information gathered from a given pilot project that might be effectively used to improve selectivity in future commercial, recreational and First Nations fisheries. The workgroup therefore considered how unique the circumstances of the proposal were, its site, the investment required, the scalability of the proposal and the employment impacts of the technology in question. Additional benefits might include data for fish management or science, or spin off benefits in new fishery support industries, tourism or educational benefits. Project design was appraised by determining whether

clear objectives were in place for the proposed project, whether it were structured to provide for supporting data to be gathered, and whether or not the proposal incorporated an evaluation plan.

The tier three evaluation criteria related to the support required. In evaluating the proposals, the workgroup considered the DFO staff hours involved in implementing the pilot, the government fiscal support required, and the allocation of fish involved.

As a result of this process, 23 proposals were subsequently approved in principle. These proposals, and some subsequent proposals, were then reviewed further by DFO's Science Branch to make sure that they were, as a group, consistent with conservation objectives. The Science Branch appraisal also considered the proposals individually and a range of recommendations were made as to the best way these projects might be carried forward with conservation, particularly coho conservation, in mind. Final design of the projects was then completed and, with some exceptions, the experimental pilots were then implemented during the 1998 season. Pilots that did not get implemented were in some cases combined with other proposals or delayed until next year.

Our summary of projects and results follows in several sections:

- Recreational Experiments
- Gillnet Modifications
- Seine Modifications
- Troll Gear Modifications
- Fish Wheel Experiments
- Reef and Trap Net Experiments
- Beach Seine Experiments
- Other Experiments

Recreational Experiments

Coho Avoidance Strategy—Area One

In area one, a coho-avoidance strategy was pursued, involving cooperation between the Department and area lodges. The Department worked closely with the lodges to monitor encounter rates. When and where these rates rose sharply, fishing effort was diverted to different locations. Some lodges also posted information for anglers regarding areas of high coho abundance, asking their clients to avoid these areas. Various gear adjustments were also made to re-

duce encounters. Larger cut plug herring and the use of downriggers were found to help this effort. Formal evaluation of results in this area are not yet complete, but early estimates suggest that success in avoiding coho encounters was high on guided vessels and mixed on unguided vessels.

Post-release Mortality Study—Work Channel

In areas three and four, there was an experimental fishery incorporating a post-release mortality study. Three professional fishing guides were hired to capture coho for the study, which was conducted in the outer portions of Work Channel north of Prince Rupert for nine days during September 1998. Each boat was set up with four rods—two rigged with single barbless hooks and two with tandem barbless hooks—each baited with cut-plug herring and fished using a motor-mooching technique. (In motor mooching the bait is trailed astern and the boat's power is used to maintain a slow movement through the current. This technique differs from trolling, in which the bait is pulled more quickly through the water, and "still" or "California" mooching, in which the bait drifts with little or no use of boat power to influence its movement) Preliminary results indicate short-term (0-24hr) mortality in the 26% range for both the single barbless and tandem barbless gear. This is higher than that reported for coho caught on trolled cut-plug herring and lower than that reported for coho caught on still mooched cut-plug herring. There is some suggestion that this may be due to the higher percentage of deep-throat injuries resulting from the motor-mooching technique relative to the troll technique. (A high percentage of the short term mortalities in the 1998 experiment were due to deep throat injuries resulting from the fish swallowing the bait.)

This mortality rate is also significantly higher than the 10% catch and release mortality rate typically applied to this fishery, a figure derived in part from slow-troll experiments carried out in 1991. And given that the experiment was carried out by professional recreational fishers under very specific landing and handling conditions, it is thought that motor-mooching mortality rates might actually be higher in the Prince Rupert/Chatham Sound sport fishery at large.

Coho Avoidance Strategy—Areas Three and Four

In areas three and four, an avoidance strategy was used similar to that in area one. Here, however, the effort was facilitated by the fact

that the fishermen were dominantly from Prince Rupert. As a result of not being "captive" to the area (as lodge fishermen are) fishing effort was more easily diverted when coho abundance was high.

Experimental Red Zone Fishery—Telkwa/Smithers

There was also an experimental red zone fishery in the Telkwa River near Smithers. Two small areas were open, one at Chicken Creek and the other at the confluence of the Telkwa and the Bulkley. The intention of these experiments was to determine which gear caught the most coho, with a view to disallowing this gear in future. Preliminary results from Chicken Creek show low coho encounters (310 pink, 5 steelhead and 6 coho). No coho salmon were caught on fly rods, and of gear rods, most coho were caught using spoons, followed by spinners. At the Telkwa, preliminary results show very low catch overall but higher coho encounters (12 pink, 15 coho and 34 steelhead). Only one coho was caught on a fly rod during the Telkwa opening. Of gear rods, most coho were caught using spinners, followed by spoons.[43]

Direct Fishery on Enhanced Stocks—Braverman Creek

Understanding that there were to be directed coho fisheries only where these would take 100% enhanced stock, managers opened only one of these. A directed coho recreational fishery was opened at Braverman Creek. Final catch numbers are not yet available.

Experimental Red Zone Fishery—Areas 19, 20 and 29

On the south coast, experimental red zone fisheries were held in Areas 19, 20 and 29. Areas 19 and 20 were open only very near the shore, which preliminary results suggest kept coho encounters to a minimum. In Area 29 at the mouth of the Fraser River, there was an experimental recreational fishery from August 26th to October 26th using sockeye gear. Preliminary results suggest that the use of this gear—in that location at that time of the year—is a successful strategy in avoiding coho encounters. (In approximately 30 boat days, only 2 coho encounters.)

[43] Cascadia Natural Resource Consulting (1998).

Direct Fishery on Enhanced Stock—South Coast

There were a number of directed terminal fisheries on marked hatchery coho stocks only. These fisheries took place at Pallant, Chilliwack, Chehalis, BQ, Stave, Norrish, Deroche and Porposie Bay.[44]

Gillnet Modifications

Multi-Panel Net—Lower Fraser River (William Mark Petrunia, GNSC02)

Building on previous work, this proposal involved the use of a gillnet with three separate 25 fathom panels: a 7" control, a 3.5" multifilament net, and a 3.5" monofilament net. The upper section of all three panels consisted of 17 inch webbing intended to allow the escapement of steelhead.

The target species was chum, and the net was fished in late November until December 6. After a total of 18 fishing days, Petrunia caught 310 chum (tagged and released) and 14 coho, all released in good condition. Seals killed three fish, but there were no net kills. This is attributed to careful handling and short set times. Comparisons between the various panels of the net suggest that the 7" control was almost twice as effective as either of the 3.5" nets in capturing chum, while capturing none of the coho. Between the two 3.5" nets, the multifilament net caught more chum and less coho than the monofilament net. All coho caught were tagged and released in good condition.[45]

Multi-Panel Net and Weedline—Lower Fraser River (Fraser River Modified Gillnet Working Group, GNSC03)

Building on results from 1997, three vessels took part in this experiment to test whether steelhead catches would be eliminated by the use of a weedline. Two nets were tested. The first consisted of a 50 fathom control panel with 7¼" mesh hung at 3:1, and a test section hung on a 210 inch weedline. Another version of the net replaced this weedline with a panel of 24" mesh (large enough for the steelhead to pass through). The testing locations were in the

[44] DFO (1998bb).

[45] Triton Environmental Consulting (1998), p. 77.

Fraser River, at the Alex Fraser Bridge, between the Patullo and Port Mann bridges, and at Hammond.

Fishing was conducted from November 8th to 27th. A total of 80 sets produced a total catch of 1316 chum, 3 coho (1 released in good condition, 2 in fair), 1 steelhead, 6 chinook and 22 sturgeon. The species in concern (coho and steelhead) were caught in too few numbers to draw any definitive conclusions about the weedline.

Various Gillnet Modifications—Barkley Sound (Industry Technical Committee on the Selective Harvesting of Salmon, Gillnet, GNIP01)

The Industry Technical Committee on the Selective Harvesting of Salmon was formed to coordinate selective fisheries work and develop a multi-year plan which includes education, communication and training programs. The ITC submitted a comprehensive proposal in 1998 to modify gear and fishing techniques for all three commercial gear types. This section addresses the gillnet component of that proposal.

The gillnet proposal involved assessing different mesh sizes, hang ratios, net lengths and soak times. The experiment was to be conducted in conjunction with Science Branch. Testing was proposed for Barkley Sound and Johnstone Strait. Due to insufficient sockeye for harvest, the Johnstone Strait experiment did not proceed.

The Alberni Inlet was the best site to test post-release mortality. Fish were removed to observation pens for evaluation of short term post-release survival, as well as tagged for evaluation of longer term survival rates (tagged fish are counted as they return to the spawning grounds). Hang ratio and soak time were also tested. A 30 minute control was tested against 45 and 60 minutes, and a 2.15/1 control hang ratio was tested against 2/1 and 2.3/1. The experiment was carried out from the 10th to the 16th of September, and six gillnet vessels were involved.

Preliminary results show a gillnet catch of 1,446 coho during the fishery, with an aggregate mortality rate of 37.4% at encounter. Adding the mortality among fish released to observation pens, the short term post-release survival rates of gillnet caught coho is estimated at 52.6%. This figure compares favourably with the 60% coho "standard" mortality rate associated with conventional gillnet gear. Note that as tagged fish are retrieved nearer the spawning

grounds, the long term mortality rates of fish caught during the experimental fisheries will become more clear.

In testing various set times and hang ratios, results suggest that for a 30 minutes set time, hang ratio is not a significant factor in changing coho mortality rates. For 60 minute sets, however, both the 2/1 and 2.3/1 hang ratios do produce significantly higher coho mortality rates than the 2.15/1 control. Finally, for the 2.15/1 hang ratio, set time does not significantly change mortality rates.

Seine Modifications

Seine Team Fishing—Areas One and Three (North Coast Seine Reps, SNNC03)

This proposal involved the fishing of three-vessel teams. For each team, only one net could be in the water at any time. The fishery would incorporate mandatory sort and release, and would target only sockeye, pink and chum.

Ten groups of three vessels each fished areas 1 and 3 (2 days fishing area 3 and 1 day fishing area 1). Preliminary results indicated less than 5% mortality. One group of three fished for 1 day in Area 6. Results have yet to be tabulated.

Preliminary internal impressions of this project were that it did decrease competition among participants and slowed harvest down as a result. In this respect, it represented an improvement over conventional seining patterns and might hold promise for the future. There would likely be many willing participants if this experiment were tried on a larger scale.

Various Seine Gear Modifications and Handling Techniques—Barkley Sound (Industry Technical Committee on the Selective Harvesting of Salmon, Seine, SNIP01)

The ITC also submitted a proposal for experimentation with modified seine gear. The proposal involved assessing several different brailer designs and selectivity grids. The experiment was to be conducted in conjunction with Science Branch, and also proposed for Barkley Sound or Johnstone Strait. The Alberni Inlet was chosen for the same reasons as it was for the gillnet experiment above. The site was considered best for testing post-release mortality. The testing was carried out at the same time as the gillnet experiment and in-

volved seven seine vessels. The standard bunt and brailer were used as a base case, and ramping, selectivity grids, sock and side-purse brailers were tested against this control. (Selectivity grids provide an escape hatch to juvenile salmon in the bunt of the net. Sock brailers release fish into a sorting tray through a sock-like tube. Side-purse brailers hold water in them as the fish are transferred.)

Preliminary results of the seine experiment show seine harvests of close to 17,000 coho. Encounter mortality rates were very low, at 0.14%. As with the gillnet experiment, some of the live coho were removed to holding pens for observation. Adjusting for the mortality rate among those fish provides a further preliminary mortality estimate of 7.2% for seine-caught coho released into the wild. This number compares very favourably with the "standard" coho mortality for seine gear of 25%. As tagged fish are retrieved nearer the spawning grounds, long term coho mortality rates will be estimated.

Of the various gear configurations tested, no one emerged as definitively better than the others. Statistically speaking, after the netpen observation period, there was no significant difference in coho mortality rates between any of the techniques including ramping. Some suggest that the slower, non-competitive nature of the test fishery contributed to the unusually low mortality rate that was recorded for ramping.

Troll Gear Modifications

Troll Gear Modifications—Masset (TRNC01)

A selective troll fishery was proposed in the area 1 red zone. The conventional troll gear would be modified to use 6 lines with 1 hook per line targeting chinook. The experiment did not proceed due to a late start and lack of participation.

Various Troll Gear Modifications—Barkley Sound (Industry Technical Committee on the Selective Harvesting of Salmon, Troll, TRIP01)

The ITC also submitted a proposal for experimentation with modified troll gear. The proposal involved assessing various hooks types with different corrosion rates, barbed vs. barbless hooks, hook covers and in-water retrieval tanks. A modified version of the experiment was to be conducted in conjunction with Science Branch. As with the seine and gillnet proposals, testing was proposed for Barkley Sound, although Alberni Inlet was ultimately chosen. The test was

carried out from the 22nd to the 26th of September. Six troll vessels were involved in the experiment. The test compared various handling methods including dip netting directly from the waterline to a revival box and dip netting to a skiff tank for removal to observation pens to emulate release by cutting the leader.

The preliminary results of the troll-caught coho selectivity study found that of the 346 encountered, the 'at catch' coho mortality rate was 2.9%. After factoring in the mortality of fish in the observation pens, a preliminary estimate of short term survival in the wild of 19.2% is derived. This number compares favourably with the standard mortality rate of 26% for coho caught by conventional troll gear. There was no statistically significant difference between the variety of handling techniques tested.

Fish Wheel Experiments

Fish Wheel—Skeena Mainstem (Gitsksan Wet'suweten'en Watershed Authority, FWNC04)

The Gitksa'an have operated a fishwheel in the Babine for a number of years, and submitted a proposal in 1998 for the installation of a wheel in the Skeena Mainstem. The wheel would target sockeye and pink. In October this project was approved. In December, planning was still underway.

Fishwheel—Kitselas Canyon

The Skeena Fisheries Commission has been working with fishwheels in the Kitselas Canyon for 5 years. This year, two wheels operated in the canyon (Skeena River, above Terrace) from Aug 19 to Oct 09 for a total catch of 1779 sockeye, 522 coho, 2968 pink, 286 chum, 3 chinook and 190 steelhead. The wheel also caught 887 Jack sockeye and 901 other species including trout ,char, and eels. All coho were released and the sockeye were utilized for food.

Fish Wheel—Yale (Yale First Nation Fisheries Stewardship Authority, FWSC01)

The Yale proposal called for the construction and operation of a fish wheel for use in sampling, tagging and selective release of Fraser sockeye, coho and chinook salmon. The wheel was also seen as an opportunity to train Yale First Nations Fisheries Technicians in the operation of fishwheels and biological sampling techniques.

The Yale wheel is situated against the wall of the Fraser Canyon near the town of Yale, north of Hope. This is a site with a powerful downstream current, but also at the edge of a back eddy, which allows for adjusting the position of the wheel and the velocity at which it turns. The wheel is of all-aluminium construction, pontoon mounted, with multi-chambered holding pens and three baskets. The baskets are about 3.5 m wide by 3.5 m deep and are hung with knotless 2" seine webbing. The structure is anchored with steel cables and pins, securing each pontoon to the bedrock of the canyon wall.

The Yale wheel operated from September 11 to November 25, 24 hours a day, 7 days a week with only 2 non-operational days. The holding tanks were emptied twice a day by a team of four people. Catch was sorted and counted by dipnet, coho were DNA sampled, steelhead were radio tagged, and all species were then released. Total catch to October 25 was 1011 sockeye, 378 coho, 104 chum, 31 chinook, 131 steelhead, 8 sturgeon and an assortment of other species. Steelhead catches were fairly consistent over this time at 1-4 per day. Coho catches were as high as 20 a day.[46]

Overall, the wheel was thought to be effective in the capture, tagging and healthy release of non-target species.[47] The 2" mesh in the baskets allowed smolts and small resident species to escape capture entirely. Optimum rotation rate was thought to be around 3 rpm. Some concerns arose about water depths at this site, and the solution is thought to be the identification of alternate sites where the wheel might be efficiently moved.

Power-Assisted Fish Wheel—Annacis Slough (Fraser River Fishermen Society and individuals from the Lakahahmen Nation, FWSC02)

This consortium proposed construction and operational testing of a power-assisted wheel at Annacis Slough and in the Fraser at Queens Island. The objective of this experiment is, in part, to test how power assist systems might be used to allow fish wheels to operate in areas with insufficient current to turn the wheel alone. This wheel is also intended for use in stock assessment, harvest, selective release and training. The wheel would target sockeye and chum.

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[46] Triton Environmental Consulting (1998).

[47] Triton Environmental Consulting (1998).

The wheel would be the largest of those proposed or tested on the Fraser in 1998, with four baskets 4 m wide by 4m deep. It will be mounted on 12 m pontoons, 3 m wide and deep. Given the water flow characteristics of the proposed test sites—relatively low—this wheel will incorporate lead nets. Power will be supplied by hydraulics from an on-shore power source to decrease the noise level, which might deter fish from approaching the trap. Once operational, it will be monitored 14 hours a day.

This proposal was approved in October 98 and construction of the wheel was begun. In December 98, construction was still underway.

Fish Wheel—Fraser River near Chilliwack (Skway First Nation, FWSC09)

The Skway First Nation, together with UBC and BC Ministry of Environment Lands and Parks applied to set up a fish wheel in Skway territory. The wheel was intended both to provide for the harvest of sockeye and chum for food, social and ceremonial purposes, and also provide a means to apply radio tags to steelhead and obtain relevant biological information on this species and sturgeon.

The Skway fish wheel site is in the Fraser River, about 3 km upstream of the confluence of the Chilliwack River. This site has a lower velocity current than the Yale wheel site, but higher than the proposed Lakahahmen/FRFS sites. Like the Yale wheel, the Skway wheel is situated at the edge of a back eddy, allowing for some control over the speed at which the baskets rotate.

The Skway wheel is slightly smaller than the Yale Wheel overall, but has four baskets about 3.5 m wide by 3 m deep hung with knotless seine webbing. It is pontoon mounted on a frame that can be raised and lowered to adjust the elevation of the baskets relative to the water. Fish are directed, after capture, into one of two holding boxes mounted to the outside of the pontoons. This wheel was built in a slough and, using an outboard motor, was moved to the fishing site under its own power. When operational, it is anchored to shore with steel cables and anchors.

The Skway fish wheel was approved in time to begin fishing in late September 1998. The project was operated under the authority of a communal licence for food, social and ceremonial purpose up to November 22, but the project then applied for a Scientific Permit to

continue the program. Total catch to October 25 was 4 sockeye, 186 chum, 36 chinook, 505 coho, 3 steelhead and 1 sturgeon (4 sockeye, 158 chum and 1 chinook were kept; all others released).[48]

There were a range of structural problems with the wheel that will be rectified. Overall, this wheel was considered a success, overall, in the capture and live release of non-target species.[49]

Reef and Trap Net Experiments

Reef Net—Kitimat Arm (Haisla Fisheries Commission, RNNC01)

The Haisla proposal called for setting up a stationery trap to harvest chums in Kitimat Arm. The trap was operational for a short time in the fall. There were a range of site specific problems that resulted in the trap being shut down. The trap caught a large number of fish at first—an estimated 200-400 chum in the first day—but at ebb tide the trap did not hold these fish and they were able to swim out of the net. It is thought that extensive site-oriented net re-design will be needed. The project was terminated and the apparatus removed from the water. No fish were sold.

Reef Net—Nitinat Lake (Ditidaht Band Council, RNSC01)

The Ditidaht proposal called for the installation of a reef net made of seine mesh—115 feet long, by 24 feet wide and 60 feet deep—leading into a 20 by 40 foot net pen suspended from log floats. Fish would be captured in the net pen, which could be closed when there were sufficient numbers, and either harvested, tagged and/or released. The net was intended to target chinook and chum, and operate with a scientific licence issued to provide for harvest. The installation was proposed for Nitnat Lake, near the narrows.

The net operated as proposed for two weeks when, due to difficulties with the anchoring system, the leads and the depth of the trap, the project was forced to shut down. The Ditidaht then deployed a more conventional purse seine net, from which the fish were transferred to the original net pen. This latter technique worked well for the purposes of catch and release. The modified operation caught

[48] Triton Environmental Consultants Ltd (1998).

[49] Triton Environmental Consultants Ltd (1998).

7000 chinook (1033 food, 5756 sale, 211 released), 34,747 chum (738 food, 32,506 sold under scientific license and ESSR, 1503 released) and 209 coho (206 released in good shape, 3 mortalities).[50]

Stationary Trap Net—DeHorsey Passage, Skeena River (Ken Kristmanson, TNNC03)

The proposal involved setting up a stationary fish trap in the DeHorsey Passage on the Skeena to harvest sockeye and pink. The net was designed for this specific area. The initial chamber was 5 by 5 fathoms and 20 fathoms long. At the end of the trap there was an aluminium holding pen 8 feet by 8 feet by 10 feet. Two 20 fathom leads funnelled fish towards the trap entrance.

The proposal went ahead in September, after the fishing season, as a fully experimental, catch and release fishery. The trap was set at low tide and 2 commercial fishing vessels were used to hold it in position while in the water. A herring skiff was also used to tow and attach the holding pen at the end of the trap. The net and trap were monitoring continuously for a 6 hour set, and the entire trap was retrieved after that period (on the high tide slack). The time required to retrieve the trap and leads was approximately 30 minutes.

The experiment ended October 2. The trap ended up catching only a few fish per tide by the end of the experiment due in part to overall abundance issues. Part of the problem also lay with the nature of the site. 23 foot tides in the area mean that the prototype needed ongoing improvement. The structure was eventually improved and strengthened sufficiently, but this took some time and experimentation. One other concern of the operators was that the size of the knotless webbing used (3 5/8 inch) was larger than ideal. The leads, also, did not appear to funnel the fish towards the trap opening as envisioned.[51] The site was considered good, however, sheltered and suitable to this kind of an operation.

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[50] DFO (1998bb).

[51] Kristmanson (1998).

Towed Trap Net—Prince Rupert Harbour (Fred Hawkshaw, TNNC04)

This proposal called for experimentation with a floating trap towed by two vessels and tended by two additional skiffs. The towed trap net forms a large triangle—consisting of multiple chambers—that trails to the stern of the two tow vessels. Anchored, the designers intended that it might also work as a stationary trap.

In either case, as fish enter the first chamber of the trap, they are guided through successively smaller chambers into a final solid-frame holding chamber at the end of the trap. From this chamber the fish may be transferred to a floating holding pen, in they could be kept live after capture. Fishing was suggested for the Skeena mouth and approach waters.[52]

The trap was designed, constructed and delivered to the site in September 98, at which point sea trials began in Prince Rupert harbour. Media representatives were given a demonstration, although there were no DFO personnel available on the short notice provided. At the outset, there were a number of design modifications necessary. The operators also noted that the trap was difficult to handle in a cross wind or other rough weather.

Sea trials were complete by mid-October and the results were inconclusive. It was only possible to test the trap in-harbour and catch was therefore very limited.

Trap Net—Skeena Mainstem (Kitsumkalum Commercial Fishermen, TNNC06)

There are three Kitsumkalum proposals, a fishwheel, a beach seine and a trap net. This proposal called for the testing of a trap in the Skeena Mainstem adjacent to Kwinitsa. The intent of the trap was to provide for the harvest of food, social and ceremonial fish. Target species would be sockeye, pink, chum and chinook.

This proposal is still under consideration.

[52] Hawkshaw (1998).

Anchored Trap Net—Canoe Pass, Fraser River (Mowat & Mombourquette, TNSC01)

The proposal was for an in-river anchored trap net for the capture, enumeration and selective release of all species. The location of the trap was Canoe Pass in the Fraser River.

The trap consisted of a live net pen area 20 by 13 by 4 m deep. The net pen was hung inside boom logs and rested on the river bottom at low tide. Two other holding pens were fixed to the main net pen, and could be used for sorting and release by dip net. Fish were guided into the main trap by two leads, a 150 fathom mid channel lead and a shore lead of 50 fathoms. Two upstream anchors held the entire trap in place.

The trap was operational by the end of October but initial harvest were low due, in part, to low chum abundance. Other problems encountered were the build up of debris in the nets, and anchor slippage at ebb tide. By the end of its test, the trap caught 250 chum in total. Most of these fish were caught on the last day of fishing, and all were released.

There were two final days of fishing on Dec. 11 and 12, but no salmon were caught and the trap was removed on the 13th.

Anchored Trap Net—Juan de Fuca near Muir Point (T'sou-ke First Nation Phase I, TNSC02)

This proposal involved the continued testing of the T'sou-ke trap in the Juan de Fuca near Muir Point. The trap has been tested extensively over the course of the past three years—as discussed at length above—but this year the T'sou-ke people sought to scale down the trap somewhat and make it possible to deploy with fewer operators.

With this in mind, the trap was modified for this fishing season by reducing the length of the lead and removing two of the traps chambers. A removable final net pen was also fixed to the spiller, which allowed the crew to move captured fish out of the heavy current for harvest or release. In all, these changes allowed the trap to operate with a crew of four.

The trap was operational in August and September, but the Stuart sockeye run was not fished in 98. As a direct result, the T'sou-ke trap caught only three fish this year, a chinook, a chum and a sock-

eye salmon. There were continued problems with California sea lion predation as well, and anchoring remains a labour intensive and problematic undertaking in the prevailing current.

The trap was eventually moved for experimentation in the Fraser. See Phase II, which follows.

Anchored Trap Net—Lower Fraser River (T'sou-ke First Nation Phase II, TNSC02)

Phase II of the T'sou-ke Nation trap net experiment involved moving the trap for testing in the Fraser River estuary. The project was carried out in conjunction with the Fraser River Fishermen Society and the Tsawassen First Nation. The experiment was intended to test the technology in a site with more consistent fish presence as well as further develop fish handling skills and selective release strategies.

The trap was installed in the lower Fraser at Queensborough Slough and was tested from November 8th to December 4th. There was a low abundance of chum in the area, but catches were consistent. The total catch was 84 chum, 4 steelhead and 20 sturgeon, all released in the same condition they entered the trap (with the exception of one hatchery marked steelhead found dead in the trap).

Alaska-Style Floating Trap Net—Steveston (Richard Massey, TNSC03)

The intent of the project was to test a modified version of the Alaskan floating trap net in the Albion Box across from Steveston. The experiment tested whether a set of leads and wings could induce salmon to enter a small 4 foot by 4 foot opening simulating that of a real trap. The experiment was in part motivated by the desire to develop a way of delivering live-caught salmon species to market in Steveston.

The trap was set on November 30 to monitor fish movement through the lead and enumeration area. Fish were monitored passing through the lead. In early December a small catching pen was added to aid in determining if the salmon are passing through. There was no catch, other than a single flounder, but knowledge and experience was gained.

Drift Trap Net—Area 29 (Tsumura & Godin, TNSC07)

This trap was inspired by the free floating traps used in lake fisheries for fisheries research since the early sixties. The lead is deployed off a gillnetter, in a similar fashion to a gillnet, except that there is a trap at the outside of the net (which itself, then acts as a lead). Fish that avoid the net (the lead) and swim along its length would be captured in the trap. The project called for the involvement of six gillnetters, and the BC government worked collaboratively on the proposal.

Two designs have been prepared for testing in mid December. In one, the trap is formed by a box 6 by 8 by 10 feet deep with a rigid back frame (3" mesh so as not to gill the fish). The central lead is designed so that fish will be guided to the trap regardless of which side of the lead they encounter. In the other design, the box is smaller, 5 by 8 by 10 feet deep. The box is also connected to the lead in such a way that fish may only enter the trap from one side. This version of the trap is fished more like a conventional drift gillnet in that respect.

Recovery of the trap is expected to be by gillnet drum, although the experiment will focus in part on determining the best methods of deployment and retrieval. If taken in to the drum, the box may be raised to a level that dip netting or brailing is possible, alternately, a boom might assist recovery of the box.

Anchored Trap Net—Canoe Pass, Fraser River (Diakow & Wilson, TNSC08)

This trap involves the use of 25 fathom leads and a square trap made of seine web, designed to concentrate the fish near the surface where they might be moved across into a sorting pen. This trap was been designed, built and ready for testing by December 7. The site chosen was at the old Brunswick cannery site in Canoe Pass, in part because of pre-existing structures that might be used for anchoring. The water in the area was not clear, and the trap was used only for enumeration. During testing in mid-December, no salmon were caught, but the trap stood up to high currents and extreme weather.

Floating Trap Net—near Hope (Fraser River Fishermen Society, TNSC09)

The FRFS filed a joint application with members of the Katzie and Kwantlen First Nations for a floating fish trap to tag salmon and

sturgeon. The trap was originally proposed for the lower Fraser between the river mouth and the bridge at Hope, although the Stave River was later chosen as a preliminary test site. It is a mobile trap, intended to take advantage of changing conditions and opportunities and yet remain within the boundaries of the scientific/experimental permit. The trap design was to draw on the experience of the Mic Mac First Nation in New Brunswick, who have operated a trap for Atlantic salmon on the Miramichi River for a number of years. The construction of this trap was funded in part by Fisheries Renewal BC.

The trap structure was mounted on two 45 foot pontoons which support a 20 foot wide platform. The trap itself is a dropping cage 16 feet wide, thirty feet long, which sinks to a depth of 10 feet, or less, depending on water conditions. The front of the cage is then opened in the path of salmon, who are guided by a system of lead nets towards the .5 by .5 metre entrance into the trap. The inside of the trap is to be made of knotless seine web giving maximum protection to the fish, and a live box will be located on the deck to facilitate sorting and tagging and to ensure that proper resuscitation is possible. The trap as proposed could be used for harvest or selective release, and could target sockeye or chum.

The testing site in the lower Stave encountered some problems. There were large numbers of chum carcasses drifting downstream, and in the end, total catch for 6 fishing days at the Stave site was only 4 chum, 3 coho (all released in good condition). The problem of low numbers of fresh-run salmon might have been exacerbated by the original 24 hour a day monitoring plan. Not unlike the findings at various other fish wheel and trap projects, the constant presence of a boat may discourage fish from approaching the trap. Monitoring was eventually reduced, and the trap was relocated to Queensborough Slough near the new site of the T'sou-ke trap. The Queensborough Slough site did not significantly improve matters, and the plan at the time of writing was to move the trap to the Brownsville Bar in mid-December.

Trap Net Site Survey (Metlakatla Development Corp.)

A proposal was submitted calling for joint work with the T'sou-ke Band in surveying potential trap net sites and working with a consultant to plan a trap net. The discussions and planning relating to this proposal continue.

Beach Seine Experiments

Beach Seine—China Bar, Skeena Mainstem (Kitsumkalum Commercial Fishermen, BSNC01)

This proposal called for a large beach seine, hauled in by trucks. The seine would target Skeena River sockeye and pink. It would be located near China Bar in the Skeena Mainstem.

There were some science concerns with this proposal. As a large scale beach seine requiring hauling by truck across the large gravel bar at the site, its live capture and selectivity qualities have been subject to some question.

The Kitsumkalum are presently in discussion with the DFO regarding their proposals.

Beach Seine—Derby Reach (Fraser River Fishermen's Society Beach Seine, BSSC03)

This proposal called for the further testing of a beach seine in conjunction with members of the Katzie, Kwantlen, and Lakahamen First Nations. Earlier tests of this particular beach seine are discussed in detail in earlier sections of this report. Operation of the net this year was intended to provide further training in handling this gear, and target late run sockeye and chum for the Kwantlen and Katzie First Nation food fisheries. The chosen site was in the Fraser River at Derby Reach, where beach seines have been tested since 1996.

In addition to the basic technology as described above, the group also used a recovery box this year. The box consisted of an insulated tote with a continuous water supply. This provided an opportunity to assess the health of fish before release. After testing in October and November of 98, operators estimate that at peak efficiency the Derby Reach beach seine set took 15 minutes to set and harvested approximately 200-300 fish a set. Catch over 23 fishing days totalled 4567 chum (2827 for food), 159 coho, 5 chinook, 3 steelhead (radio tagged) and 2 sturgeon. Some of the chum were kept to meet FSC requirements. Of the coho, 152 were released in the best possible condition, meaning no scale or other damage was evident.

Beach Seine—Matsqui (Matsqui First Nation)

The Matsqui First Nation has been conducting beach seine activities in their territory, under scientific permit, since 1995. The operation this year was intended to provide fish for food, social and ceremonial purposes. The net, in this case, is 300 feet in length and is set off an 18 foot river skiff. Total catch to November 15, after 4 days of fishing, was 34 chum and 2 coho (both released in good condition).

Beach Seines—Lower Fraser River (Various Fraser River First Nations Groups)

Since the introduction of the coho conservation measures on the Fraser River, a number of the lower Fraser nations have applied to conduct selective fisheries for chum using beach seines. DFO authorised a total of nine of these from five different bands between Port Mann Bridge and Sawmill Creek. These fisheries happened between Sep 1 and Nov 22. Catches of chum in these fisheries varied from group to group, however all non-target species were released alive and unharmed. As part of the conditions of license for each of these fisheries a monitor, hired by DFO, was present at all times during all fisheries.

Other Experiments

Fish Weir—Sugsaw Creek near Bamfield (Huu-ay-aht First Nation)

This proposal called for a fish weir on Sugsaw Creek, a few kilometres northeast of Bamfield. The proposal was approved and construction was underway in October. The weir fished in late October, and salmon were enumerated and collected for brood stock. The chum run to this creek was estimated at 450-500 of which 100 males and 100 females were captured for brood stock. Additionally, 9 coho and 2 chinook were taken for brood stock. The better quality carcasses were used for food.

Pump Transfer System—Sechelt (Sechelt First Nation)

This was a proposal for a pump to transfer salmon from a seine to a net pen. It was to be tested against conventional brailing and a control. The system is similar to those used to extract fish from pens in aquacultural operations: a pump with an 8000 piece per hour maximum capacity and an 8" wet hose with a counter system. The

pump passes the fish through to a grading and sorting table, from which juveniles may be released through a grate back into the net pen. The table leads to a 12" output pipe.

The pump was tested in late October for immediate and seven day mortalities. Preliminary results showed no immediate mortalities and minimal scale lost. Post handling mortalities were less than 1%.

[Return to Selective Fishing]

EVALUATION OF MEASURES

[Return to Sel ective Fishing]

Evaluation Overview

In this section we provide an evaluation of the readiness for implementation of various seine, gillnet, troll, alternative gear and recreational selective fishing measures. This evaluation is made against the following set of criteria:

CATEGORY	CRITERIA	DESCRIPTION
Effectiveness	Catchability	Measure can successfully harvest at volumes appropriate for its fishery
	Selectivity	Measures is successful at avoiding or releasing alive and unharmed fish of species of concern
	Species Applicabi lity	Measure can be used to fish selectively salmon species other than coho
	Geographic Mobi lity	Degree to which a measure can be applied at different locations in the fishery or, conversely, degree to which a mea sure is site specific
Economics	Cost	Capital and operating costs associated with the meas ure
	Viability	Evaluation of ability to catch fish and cost of the mea sure
	Labour Impact	Jobs and labour costs
Management	Manageability	Measure can be effectively managed in the context of existing fisheries and DFO programs
	Enforceability	Measure can be effectively enforced in the context of existing fisheries and DFO pr o-grams
	DFO Cost	Incremental DFO costs required with the measure under consi deration
	Cost Recovery	Degree to which the measure is amenable to cost recovery mecha nisms
Other Factors	Knowledge	Potential of the measure to identify new knowledge about the species in ques tion
	Implementation	Hurdles that a measure may face during implement ation
	Environmental	Impacts associated with implementation of the measure (relative to existing fisheries).

For some measures, quantitative performance data is available, but in many cases experiments in 1998 either were not completed or the results were inconclusive. As a result, the evaluation in this sec-

tion is qualitative. Comments on individual measures are based on the experience of fishermen and the DFO over the course of the past few years.

For each sector or gear group, the evaluation of selectivity measures is structured in three parts. First, the measures are introduced and briefly defined, and some comment is provided regarding criteria that are common to all measures. Second, the measures are evaluated in turn, in a narrative discussion of the measure against the above criteria. Third, these results are summarized for the sector, identifying the measures ready for implementation and those holding promise for the future.

Seine Measures

The seine selectivity measures evaluated are drawn from the experimentation that has gone on over the past 5 years, with particular focus on the projects and experience gained during 1998. These selective seine measures fall into four main groups, which correspond to different aspects of the fishery.

GROUP	MEASURE	DESCRIPTION
Net modifications	Knotless bunts	Smooth seine net webbing designed to reduce scaling
	Selectivity grids	Allow the escape of juveniles and small species from the net through grids installed in the net bunt
Bringing the catch aboard	Brailing	Dip netting the catch from the seine to the deck in small numbers to avoid crushing and scaling
	Side-purse brailing	Type of brailing – uses a semi-porous brailer that keeps water around the fish as they are lifted from the seine net
	Sock brailing	Type of brailing – uses a brailer with tube through which the fish are gently transferred to the sorting area
	Pump transfer	Uses a pump to move the fish from the net to a sorting area
Post-Capture	Sorting/Handling	To ensure the separation of non-target stocks in a manner that maximizes post-release survival
	Revival boxes	Tanks with circulating oxygenated water to help the fish revive before release
Management techniques	Time and area closures	Opening and closing fisheries to harvest "clean" stocks and avoid stocks of concern. opening and closing fisheries to harvest "clean" stocks and avoid stocks of concern.

	Team harvesting	Vessels harvesting in teams to reduce the pace of the fishery and provide time for other measures, such as sorting and correct ha ndling.

Against some of our evaluation criteria—species applicability, mobility, labour impact, cost recoverability and environmental impact—these measures are more or less equivalent. All but one of these techniques are applicable to all species (ie, they might be used to live release coho or steelhead or any other salmon species as necessary). The one exception to this is the selectivity grid, which is size specific and would not be useful if the non-target species were of the largest size. All measures are mobile in the sense that they can be implemented anywhere on the coast.

Similarly, labour impact is uniform across all seining measures. Although many of these measures slow the process of seining, and so have an impact on the overall effort required, none would necessitate additional crew. All measures look more or less the same with respect to cost recovery as well. And finally, assessing the incremental environmental impact of the various measures does not set any one apart. The measures that slow harvest rates—brailing, team harvesting, sorting—could have an impact in the sense that vessels might have to run longer, and therefore would create more emissions from internal combustion engines, but this effect is thought to be small.

With these points in mind, we focus our discussion of seine measures on the remaining criteria.

Net Modifications

Designed effectively, both selectivity grids and knotless webbing should have very little impact on overall catchability of the gear. Selectivity grids do allow smaller fish to escape, but these would presumably be fish that would have to be released after harvest anyway. In terms of selectivity, the measures are complementary. The results of the Alberni Inlet experiment of 1998 confirmed that grids promote avoidance selectivity and knotless bunts promote post-release selectivity. Grids were observed to allow the escape of almost all the undersized salmon, possibly 95%. The knotless 2" mesh, meanwhile, was observed to result in less damage to all species.

From the standpoint of economics, there is a capital cost associated with both net modifications. Selectivity grids are typically molded plastic, approximately 2 feet by 3 feet, and four or five of them must be sewn into the net. Knotless bunting, of course, requires that this part of the net be replaced.

The manageability and enforceability of both measures is considered high. Neither requires a significant deviation from the present management framework. And both of these measures could be accommodated within the existing enforcement framework. There should be no incremental cost to DFO from implementing either net modification.

There is likely little additional knowledge about salmon species to be gained from the knotless webbing. Of the two, knotless webbing is likely the easier to implement. Once the net is changed, there is little difference in the practice of seining thereafter. The grid might require some further education, with regards to how it is deployed, and how it should be handled as it comes back onto the drum. There are also a number of outstanding design questions about the selectivity grid—colour, size, materials etc—and further work would likely lead to improvements.

Selectivity grids may be useful only for specific fisheries where the non-target bycatch is smaller than the target species.

Bringing the Catch Aboard

There have been a number of tests designed to improve selectivity when taking the fish from the purse seine to the deck. In this section, we look at standard brailing—vs ramping and various 'improved' brailing methods—and the pump transfer method.

Brailing, in general, is thought to be more selective than ramping, while imposing certain restrictions on overall catchability. Selectivity benefits are derived primarily from the reduction of crushing, which can occur if large purse seines of fish are pulled up using a stern ramp, and emptied on the deck at once. Brailing also contributes to selectivity once the fish are aboard. Since a succession of smaller loads of fish are put on deck and sorted at any given time, crew that are brailing typically have more time to apply careful handling and sorting practices. Sock brailers and side-purse brailers are generally

thought to be the best of the range of brailers under consideration. They increase the basic selectivity of the knotless brailer through the addition of features (in the one case holding water in the brailer as it is lifted, in the other a tube for easy transfer of the fish to the sorting area). In the Alberni Inlet experiments, both these brailer types were observed to virtually eliminate scale and stress damage to the fish.

Brailing, however, does have a negative impact on overall fleet catchability. Regardless of the specific brailer chosen, it slows the fishery down, adding 30 minutes or more to a set. In this respect, it is an indirect cost to both skippers and crews, equivalent across all brailing methods. But it is also a direct cost to vessel owners in that it requires new hardware. Brailers of the various kinds under consideration cost from $300 to $700. Compared to a hydraulic stern ramp—costing as much as $100 thousand—this is a relatively minor investment. In cases where a stern ramp is already in place, the sunk cost of that improvement will have to be borne by the vessel owner.

The manageability and enforceability of brailers is considered high. There should be no incremental cost to DFO from implementing any of the brailer designs and little additional knowledge about salmon species is likely to be gained from the use of brailers.

In terms of ease of implementation, brailer designs set themselves apart from one another. The fleet is probably most familiar with the standard knotless brailer at this point, and so it lends itself to easy implementation. The other two designs are experimental, and will warrant further testing under commercial conditions and possibly design improvements. Based on the Alberni Inlet experiment, however, there is a sense that the wet brailer will be the most difficult for crews to handle. It is the heaviest (being full of water) and in rough weather it will swing (an issue of increasing importance, the smaller the vessel). The standard knotless brailer avoids the weight problem by being dry, but it will still swing in heavy weather and is likely a small degree less selective. The sock brailer won't swing (the 'sock' is anchored in the sorting box) but it is likely the most expensive of the three kinds of brailers. Viability of the three, therefore, is likely a vessel specific issue. It is also worth noting that, in sets of a very small number of fish, brailing and ramping might produce similar results in terms of selectivity. More experimentation is warranted here.

Pump transfer methods warrant separate discussion. Against our evaluation criteria, this technique measures up quite differently than brailing at a number of points. The technique is similarly selective. Experimental results from the Sechelt Nation showed no mortalities and minimal scale loss and bruising. Overall post-release mortality rates were similar to the Alberni seine results at under 1%.

The direct capital costs imposed on vessel owners, however, would be significant. The Sechelt experiment involved a silkstream pump with an arrangement of sorting tables and wet-pipe inputs and outputs. The 1998 was budgeted at over $200 thousand. We recognise this amount includes operating and other costs but, overall, consider the method to be significantly less viable in the near term than brailing.

It also seems likely to present a number of difficulties in implementation were this machinery actually mounted on the deck of a seiner, and well might not fit on the decks of smaller vessels. Familiarity with the technique (outside aquacultural circles) is low.

Post-Capture

The selectivity of sorting and handling techniques, and the use of revival boxes, is highly dependent on the crew having been instructed and educated on correct technique. Assuming this has been done, sorting, handling and the proper use of revival boxes—particularly used together—are considered a very effective way of reducing post-release mortalities of seine caught non-target species. Similar to brailing, they also reduce the catchability of a vessel in a given length of time by significantly slowing the fishery.

Proper sorting and handling practices impose no additional direct cost on vessel owners. Revival boxes involve a small additional investment. The viability of both measures is considered excellent (especially if the time required to properly handle and sort fish is taken into account, and additional time is allotted to compensate).

Both techniques can be enforced with significant additional costs, and both could contribute to our knowledge of the species of concern by facilitating scientific efforts such as tagging and sampling.

In terms of ease of implementation, all these measures are rated highly. Revival boxes in particular are now somewhat familiar to the fleet, and there is a high level of acceptance for their continued use. Handling and sorting practices are much more dependent on education and continued improvements.

Management Techniques

Team harvesting and time/area closures have positive but different impacts on selectivity of the seine fleet. Time/area closures are an avoidance technique, and team harvesting is a post-release selectivity technique (intended to provide individual vessels with the necessary time to brail, sort, revive and release properly). By slowing the fishing process, team harvest also has a direct negative impact on fleet catchability in a given period of time. Time and area closures may or may not impact the catchability of the fleet, depending on opportunities to fish where the target stock is separated from any stocks of concern. Typically, this will not be possible for all target stocks and therefore catchability can be expected to drop. Successful post-release selectivity measures are the only measures that can ensure access to all target stocks.

Neither management technique implies higher capital cost to vessels. Both will reduce viability somewhat by reducing catch over time.

Where these selectivity measures stand out is with regard to management evaluation criteria: manageability, enforceability and DFO cost. Both techniques would involve significant pre-season communication with stakeholders, planning, and on-the-grounds changes in the way DFO carries out its monitoring and enforcement functions.

Given that team harvesting slows the fishery, and provides time for careful sorting and handling practices, this measure might facilitate scientific efforts such as tagging and sampling.

Of the two, time and area closures are likely the more easily implemented. The fleet is familiar with the practice, and there is little change required in the manner of fishing once fishing does commence. Team harvesting presents various obstacles to implementation. The process is far less familiar to license holders at present, and the process by which it is implemented must be open to all relevant

license holders. With this in mind, further communication and education will be necessary.

Summary

Of the two net modifications—knotless bunts and selectivity grids—knotless bunts are likely the easier to implement in the short term. Grids would benefit from further experimentation, both to educate fishermen as to their use and inform future design improvements.

Brailing techniques improve selectivity and may be had for a modest capital cost, but they slow the fishery significantly and work differently under different circumstances. Brailing in rough weather, for example, is more difficult with wet brailers than sock brailers, while the sock brailer likely costs more. The solution in this area might involve giving fishermen a certain degree of flexibility in choosing a brailing technique.

Given that seiners can bring the catch aboard in very good condition, through the use of various selectivity measures, some seiners feel that sorting, handling, revival and release techniques are where the greatest effort should now be focussed. This comes down to education, and the development of a still greater conservation ethic within the fleet. Beyond this, these measures, particularly revival boxes, enjoy a degree of acceptance and present few significant obstacles to implementation.

Time/area closures have been used for some years and there is acceptance for their continued use. Team harvesting will encounter a number of obstacles in implementation. It requires significant changes in DFO's management and enforcement practices and, therefore, more communication, planning and staff resources must be committed. Team harvest is generally agreed to slow the fishery (and provide an opportunity to sort, handle, revive and release correctly) but there must be a perception of open access to all relevant license holders. Given the need to slow the fishery to apply proper handling and release techniques, team harvesting may offer one of the easiest methods to implement to achieve a slower fishery.

Gillnet Measures

The gillnet selectivity measures evaluated are drawn from the experimentation that has gone on over the past 5 years, with particular focus on the projects and experience gained during 1998. These selective gillnet measures fall into four main groups, which correspond to different aspects of the fishery.

First, some general evaluation comments. The only measure that would appear to avail itself to special consideration regarding cost recovery is the cost of mounting courses to train crew in correct release techniques. Otherwise, there are no advantages among measures in terms of cost recovery.

Similarly, with the exception of release techniques, all gillnet selective fishing measures evaluated in this section rate highly in terms of ease of implementation. Release techniques require a high degree of awareness and education, possibly including a mandatory course in fish handling for all licensed fishermen.

GROUP	MEASURE	DESCRIPTION
Managing for avoidance	Time and area closures	Opening and closing fisheries to harvest "clean" stocks and avoid stocks of co n-cern.
	Daylight fishing	Opening fisheries only during daylight hours
Gear Modifications	Alaska Twist net	A relatively new kind of net constructed of 6 strands.
	Tooth net	Net designed to catch salmon by entangling their teeth and jaws rather than their gills.
	Mesh size	Size of openings in net adjusted to select catch by size of fish.
	Weedlines	Suspending net below the surface to allow non-target species migrating near the surface to pass over the net without being tan gled or gilled
	Multi-panel nets	Multi-panel nets combine mesh size and web characteristics of different kinds into a single net.
	Net length	Altering length of net to affect catchability and facilitate shorter soak times
Fishing Techniques	Hang ratio	Amount of webbing hung on a given length of corkline.
	Set pattern	Shape of the net once it is set in the w ater.
	Soak time	Amount of time a gillnet is in the water before the fish caught in it are harvested
Handling and release practices	Sorting/Handling	Separation of non-target stocks in a manner that maximizes post-release su r-vival
	Revival boxes	Tanks with circulating oxygenated water to help the fish revive before release

No discernible environmental impacts were found to accompany any of the gillnet selective fishing measures evaluated herein.

Time/Area Closures

Time/area closures are used to close areas where non-target species of concern are present in sufficient numbers. By closing the fishery, target and non-target species are allowed to pass by. Thus time/area closures are generally very poor in terms of catchability of target species and excellent in terms of selectivity of non-target species. In some cases it may be possible to "make up" some of the catchability lost due to closures if the fishery can be re-opened at a different time and location when non-target species are no longer present.

Time/area closures are a key selectivity measure for gillnets because, at least to date, selectivity of gillnet gear has been based primarily on avoidance of threatened stocks more than releasing caught fish alive and unharmed. In 1998, time and area closures proved very effective for gillnets in avoiding coho. Time and area closures can be enhanced by involving fishermen in monitoring coho abundance and providing information to DFO as a means of keeping the gillnet fleet away from threatened stocks.

Time/area closures are highly effective for avoiding any species. All that is required is monitoring fisheries for presence of species of concern. The effectiveness of time/area closures for any species can be enhanced by including license holders in the monitoring process.

Time/area closures could be used anywhere around the coast or in-rivers as a selectivity measure. However, mobility of some of the in-river small boat fleets may be severely limited.

There is no direct capital or operating cost consequence of time/area closures to license holders; neither is there any impact on the amount of labour required in the fishing operations of license holders (apart from increased labour that may be required for proper handling of non-target species that must be released, but this is independent of the type of selective fishing measure).

Time/area closures are considered to be highly manageable and enforceable from DFO's perspective because these measures have long been a principle fishery management tool.

Time/area closures may appear to improve DFO's and license holders' understanding of migration routes and timing, but such information is not transferable over seasons. Migration timing and routes are uncertain and variable from year to year, and timing appears to be changing over time (ie, trending). In any event, it is not conceivable that time/area closures would be implemented based on pre-season knowledge without in-season monitoring and test-fishing to determine precisely whether fish of concern (target or non-target) are present in a given area at a given time.

Daylight Fishing

Daylight fishing performs moderately well in terms of catchability of target species. Some complaints have been voiced over the unsuitability of daylight fishing to in-river fisheries (eg, Skeena) because of the need to fish tides. More work is needed to document the effect of daylight fishing on harvest of target species. Daylight fishing in 1998 was not contrasted with nighttime fishing to assess its impact on catch of target species.

Several studies have shown that daylight fishing is effective in terms of selectivity for non-target coho. This is believed to be based on the relatively good eyesight of salmon species that hunt, such as coho and chinook, but presumably would not work (as) well on salmon species that do not hunt (eg, chum).

Daylight fishing is only applicable to species with good eyesight that can take advantage of the light to avoid fishing gear.

Daylight fishing is highly mobile in that it can be applied anywhere except in conditions where visibility in the water is reduced for reasons other than lack of light. Thus, daylight fishing might be less applicable to some river fisheries if there is turbulence causing sediments to obscure visibility.

Alaska Twist

Alaska Twist is a 6 strand net that is much stiffer and bulkier than the standard 30 strand net that has been used in BC for many years, but more visible than a monofilament (single strand) net. Currently Alaska Twist is not standard in BC coast-wide. In 1998, its use was

permitted in Area D between June 29 and September 15 as a condition of license (ie, for the sockeye fishery in Johnstone Strait). In the north, use of Alaska Twist was permitted as a condition of license in Areas 1, 3, 4, 5 and 101-7.

Alaska Twist would be expected to be applicable to any species and at any place fisheries are conducted.

The need to purchase new web would impose a capital cost on license holders but no incremental operating costs would be expected. These costs may be offset to some extent by the fact that Alaska Twist is tougher than standard webbing and easier to use (eg, it is easy to deal with if the net accidentally encounters weeds).

Alaska Twist would be highly manageable and enforceable as web characteristics are currently used as management tools (eg, banning of monofilament net). There is some cost to checking nets and gear but no incremental cost to DFO as these activities are already required. On-board observers would reduce DFO's cost but increased operating costs for license holders if they were required to bear the cost of the observer program.

Tooth Net

Tooth net is designed to catch salmon by entangling their teeth and jaws rather than their gills. Tooth net has a smaller mesh size to prevent gill damage, and a loose hang ratio to facilitate entanglement, and may also be combined with shorter soak times to maximize survival of non-target species.

Experiments have demonstrated that tooth net can be effective at catching target species while at the same time allowing live release of non-target species with minimal harm. Tooth net, through initial studies, indicated its effectiveness in fisheries targeting chum salmon co-migrating with non-target steelhead, chinook and coho. Further experiments are required to prove this selective fishing measure for effectiveness in regular commercial fisheries with these or other species. Tooth net can be used coast-wide.

License holders must bear the capital cost of acquiring new net, of course, but otherwise there are no incremental cost implications. No additional labour is required apart from that necessary for proper

handling and release of non-target species, which is not specific to this selective fishing measure. As tooth net may be less effective than a standard net at catching target species, it may be necessary to extend fishing time to compensate. Tooth net provides a higher quality catch than a gilling web as there are very few net-marks on salmon caught with a tooth net, resulting in a higher quality fish and therefore a higher landed price.

Tooth net should be highly manageable and enforceable, although it requires gear and net checks (which enforcement staff conduct at present to ensure compliance with current gear restrictions). There would be no significant incremental costs to DFO of implementing tooth nets as a selective fishing measure.

Mesh Size

Different mesh size is used to target species of different size. Mesh size may be used to increase catchability or selectivity. Mesh size is most often combined with other selective fishing measures (eg, tooth net, multi-panel nets).

Tailoring nets to target species or species of conservation concern by adjusting mesh size is a proven measure for increasing catchability and selectivity. Varying mesh size is applicable to all species and in all areas of the province.

This measure requires purchasing netting with the desired mesh size. The appropriate mesh could be different for each species of concern, resulting in significant capital costs. Incremental operating costs are zero and no additional labour is required. Mesh size has long been used to increase the catchability of nets and is considered an economically viable measure.

Mesh size, being an often used gear restriction in previous years, is considered to be both manageable and enforceable. No incremental DFO costs are incurred in using this measure. It is not given to cost recovery in any unique way.

Mesh size would be very easy to implement but offers no additional benefits in terms of knowledge or environment.

Weedlines

A weedline suspends a net below the surface (corkline) to allow non-target species migrating near the surface to pass over the net without being tangled or gilled.

Weedlines are one method of making gillnets selective while maintaining catchability of target species (ie, without closing the fishery entirely, which reduces catchability of target and non-target species to zero).

Weedlines have proven highly effective for avoiding steelhead. Experiments show great promise for harvesting chum while avoiding steelhead and coho.

Weedlines have proven their ability to catch sockeye and chum while avoiding steelhead, chinook and coho. They would be less useful in fisheries where non-target species swim more deeply than target species. Other specific configurations have yet to be tested.

Geographical mobility of weedlines is high. This selective fishing technology could be used around the province.

There could be a small cost to license holders for additional gear required to implement weedlines. No incremental operating cost has been identified.

Weedlines rate well in terms of manageability and enforceability. As with any selective fishing measure affecting gear, enforcement requires checking gear for compliance. As this is already an enforcement task that must be carried out by DFO, incremental enforcement costs attributable to the use of weedlines or other selective fishing measures that affect gear are not expected to be significant.

Multi-Panel Nets

Multi-panel nets combine mesh size and web characteristics of different kinds into a single net. Their purpose is to maximize harvest of target species while minimizing capture of non-target species and allowing non-target species caught in the net to be released alive and unharmed. Multi-panel nets have been successfully combined with tooth net and weedlines.

Various combinations of multi-panel nets have been tested with in the past 3-5 years with some success. Multi-panel nets have proven effective in harvesting chum salmon with excellent survival rates on non-target species. Survival of non-target species is particularly good when tooth net is used in panels aimed at non-target species. Each combination of target and non-target species requires development of new designs for multi-panel nets based on the characteristics of the species of interest.

Applicability of multi-panel nets for different species and different areas of the coast remains to be proved up via experimentation.

Multi-panel nets could increase capital costs to license holders who might be required to purchase new netting and construct new multi-panel nets. No incremental operating cost is expected.

Manageability and enforceability of multi-panel nets should be high as net characteristics are already used as fishery management tools, so DFO is already required to create gear regulations and check to ensure that license holders complying with them. No significant increase in DFO costs is anticipated for multi-panel nets.

Net Length

Net length is directly related to catchability: as net length is shortened, catchability falls. This could reduce a license holder's total catch and revenue. Some amelioration of this impact might be obtained by lengthening the duration of the fishery.

By facilitating shorter soak times, shorter nets improve selectivity of non-target species by improving survival rates of non-target catch that is released. Shorter nets are applicable to all species and to all areas of the coast.

License holders could reduce costs by saving on net purchases. License holders nets in excess of length restrictions could be used as replacement nets thereby deferring the need for purchasing new nets. No operating cost impacts of net length restrictions are expected although fishermen may have to work harder to pick their nets at more frequent intervals. More labour might be required but when the need for additional crew to accommodate proper handling

procedures for non-target species to be released is taken into account, no incremental labour requirement is anticipated.

Net length would be both manageable and enforceable as a selective fishing measure. DFO already has gear restrictions of various kinds in place and is therefore already promulgating appropriate regulations and carrying out necessary inspections of gear for compliance with restrictions.

Hang Ratio

Hang ratio is the amount of webbing hung on a given length of corkline. A higher hang ratio (ie, more web per foot of corkline) results in a baggier net. Hang ratios in the gillnet fishery usually hover around 2:1. Hang ratios are often combined with other selective fishing measures (eg, tooth net, soak time).

Experiments in 1998 indicated that hang ratio is not a significant factor in post-release mortality if soak time is short (ie, 30 minutes). At higher soak times (eg, 60 minutes) a hang ratio of 2.15:1 was shown to be superior to both higher and lower hang ratios (ie, 2:1 and 2.3:1). For the 2.15:1 hang ratio, soak time was not a significant factor. High hang ratios have also been used in past experiments that proved successful (eg, 1996 Fraser River modified gillnet study).

Hang ratios combined with other selective fishing measures can be quite successful in catching target species while permitting live release of non-target species. Hang ratios are applicable to all species and could be implemented in different locations.

License holders could incur incremental capital costs of purchasing additional web if hang ratios are increased but there should be no impact on operating costs. Economic viability would not be expected to be significantly impacted and could even rise if catchability were improved sufficiently.

Hang ratios are considered to be both manageable and enforceable. No significant impact on DFO costs is anticipated as staff are already committed to enforcing gear restrictions.

Set Patterns

Set patterns refer to the shape of the net once it is set in the water. Gillnets are traditionally set in a straight line but experiments have been done with "S-shaped" patterns, usually in combination with high hang ratios and tooth net where the objective is to entangle fish by their teeth and jaws rather than by their gills.

In combination with other selective fishing measures, set patterns can contribute to effective selective fishing. They are applicable to all species and all areas.

No incremental costs are anticipated and economic viability should therefore remain unchanged.

This selective fishing measure is considered to be both manageable and enforceable, and no significant DFO cost is foreseen.

Soak Times

Soak time refers to the amount of time a gillnet is in the water before the fish caught in it are harvested. Shorter soak times contribute to selectivity by facilitating faster release of non-target species caught in the net, thereby increasing survival rates. Shorter soak times may also contribute to improved quality of retained target species if combined with improved handling techniques.

Shorter soak times should not affect total catch but can contribute to improved selectivity. This selective fishing measure can be applied to all species and in all areas.

There is no capital cost impact on license holders and therefore economic viability is likely to remain unchanged. More labour might be needed but it is more likely the case that more work would be done by the existing crew.

Shorter soak times are considered to be manageable and enforceable by DFO. No significant incremental DFO cost is anticipated. However, labour and/or the resultant reduced fishing time may be a factor.

Release Techniques

Release techniques refer to how non-target species are handled and how they are released (eg, in the water or after transfer to a resuscitation box).

Release techniques are focused on proper handling of non-target species to maximize survival after release. Once the time is taken to properly handle fish, however, the opportunity is created for improved handling of target species with resulting higher quality product and possibly improved prices. New markets may even be tapped if fish are properly handled.

Proper handling techniques can be applied to all species and in all areas of the coast.

License holders will experience no incremental direct (capital or operating costs) but more time will be required to properly handle fish. If the fishery is not extended, this could result in reduced catch and revenue. This could be offset by extending the duration of the fishery.

Crew size may need to be increased to facilitate proper handling of catch, the more so if improved handling is extended to target as well as non-target species. In the former case (non-target species), cost may rise. This might be offset by extending the duration of the fishery to maintain or even increase total catch. In the latter case (target species), license holders can be expected to weigh the revenue and cost implications and decide for themselves whether to attempt to improve the quality of their catch by changing their handling practices.

Proper handling and release techniques are manageable but could be difficult to enforce on all vessels and at all times other than by a universal observer program. Once released fish are returned to the water, there is no evidence for DFO to assess handling and release techniques of individual crews.

Widespread introduction of prescribed handling techniques would require considerable education and training. This could generate increased costs to DFO or to license holders and fishermen if they are required to pay for their own mandatory training. This latter case

represents one of the few situations where selective fishing measures seem to lend themselves to cost recovery initiatives.

Revival Boxes

Revival, or resuscitation, boxes are used for temporarily holding non-target species that are too stressed to release immediately back to ocean or river.

Revival boxes have been demonstrated to be very effective in increasing survival of non-target species in some cases. In the gillnet fishery, the relative merits of immediate in-water release (ie, without taking the fish on-board) and revival tanks are still not clear and need further work. Revival boxes are applicable to all species and could be used in all areas.

License holders have already incurred new costs to purchase revival boxes which were made mandatory in the 1998 fishery. There is no incremental operating cost or labour requirement although revival boxes do increase the amount of time required to complete a set. This work can be done by the existing crew.

Experience with revival boxes indicates that they are both manageable and enforceable. This selective fishing measure imposes no new incremental costs on DFO.

Summary

Gillnet measures can be grouped in four categories: (1) management measures designed to increase fleet selectivity through avoidance; (2) gear modifications designed to reduce post-release mortality; (3) techniques for deploying the gillnet in the water, and; (4) handling and release practices designed to reduce post-release mortality. We examine each of these in terms of their readiness for implementation.

Management avoidance techniques are the primary tool for increasing the selectivity of gillnets. Time/area closures have been particularly effective. They involve no additional cost to the fleet, or to DFO, for whom time/area closures have always been a principal technique for managing fisheries. In 1998, time/area closures were

used more intensively, in some cases in conjunction with input from fishermen on the grounds of information on presence or absence of fish in given locations at particular times. The technique is therefore considered to have a high readiness to implement.

Daylight fishing is also considered effective in terms of selectivity for coho, but it may not be for species that do not hunt, and it has an as-yet undetermined impact on gillnet catchability of target stocks. For these reasons, its readiness for implementation is considered less than time/area closures. Further experimentation would clarify the usefulness of this measure.

Gear modifications include the use of Alaska Twist, tooth net, mesh size, weedlines, multi-panel nets, shorter nets and different hang ratios.

Of these measures, Alaska Twist, tooth net, mesh size, weedlines and multi-panel nets are the readiest for near-term implementation for coho and steelhead conservation. These measures have benefited from the greatest amount of testing, and have shown positive results. Some capital cost is imposed on the vessel owner in each case, but incremental enforcement and management costs are thought to be low. There is growing familiarity with these measures based on experiments carried out in the past five years. With these points in mind, this group of net modifications is rated high in terms of readiness for implementation for coho and steelhead selectivity, but will benefit from further testing in the case of other non-target species.

Hang ratio experiments have also been carried out in recent years, and this year. The results have been mixed, but there is some indication that, at longer soak times, the prevailing industry standard of 2:15:1.0 resulted in the highest selectivity. In general, the hang ratio must be considered along with other gear modifications and fishing techniques being used.

Shorter nets do not increase selectivity themselves, unless used to facilitate shorter soak times. These are discussed below.

Fishing techniques for evaluation include the use of different set patterns and the use of shorter soak times. Both of these measures, particularly in conjunction with other measures (such as gear modifications and changes in handling practices) have been observed to contribute to gillnet selectivity. Shorter soak times might even contrib-

ute to the value of catch by increasing landed quality. Neither measure has a significant cost impact on license holders or DFO. Although further study might be rewarding, particularly in terms of identifying which set of measures works best together, both these measures are rated high in terms of readiness for implementation.

Handling and release practices are the last opportunity for a vessel to have a positive impact on selectivity before the non-target fish is back in the wild.

Careful handling is thought to improve the chances of post-release survival by minimizing trauma and scaling. It can also have a positive effect on catch value by increasing the quality of landed fish. If a range of new handling procedures were mandated, however, the impact on operating costs of license holders, and on DFO's enforcement costs, would be uncertain. It is thought that significant communication and education would be necessary before implementation.

Revival boxes are thought to have a positive impact on selectivity in some cases, but in the gillnet fleet further experimentation is needed to compare this measure with immediate water-line release. If the measure were proven effective, it is highly implementable in other ways: the cost is low (many gillnetters already have survival boxes), and the manageability and enforceability of the measure is high.

Troll Measures

The troll selectivity measures evaluated are drawn from the experimentation in the recent past with particular focus on the projects and experience gained during 1998. These selective seine measures fall into three main groups, which correspond to different aspects of the fishery.

GROUP	MEASURE	DESCRIPTION
Managing for avoidance	Time and area closures	Opening and closing fisheries to harvest "clean" stocks and avoid stocks of concern.
Gear modifications	Barbless hooks	Crimp barb to reduce damage to hooked fish

GROUP	MEASURE	DESCRIPTION
	Large plugs	Oversize plug lures to minimize damage to fish caused by swallowing hooks
	Depth release hook covers	Exposes hook only once it reaches desired depth (of target sp ecies).
Handling and release practices	Dipnets	Use of dipnets to transfer fish from water to revival tanks.
	Release Techniques	Best techniques for freeing fish from hook so as to maximize post-release survival
	Revival boxes	Tanks with circulating oxygenated water to help the fish revive before release

Time/area Closures

Time/area closures prevent harvesting of target and non-target species and are therefore rated poor in terms of catchability but excellent in terms of selectivity (ie, survival of non-target species by avoidance or live release). The cost of complete selectivity is zero catch.

Time/area closures are applicable to all salmon species and in all areas of the province. time/area closures are one of the oldest measures used to manage fisheries, selective or otherwise.

There are no incremental capital or operating costs to license holders; indeed all operating costs are reduced to zero. With zero catch, but capital costs already incurred, time/area closures are a poor selective fishing measure in terms of economic viability.

Closures are easily managed and enforcement, given that they have been widely used by DFO to manage fisheries. No incremental DFO costs are anticipated.

Barbless Hooks

Recent experiments have demonstrated that catch of non-target species is not adversely affected by use of barbless hooks. Unfortunately, experimental results indicate that survival of non-target species, while slightly lower with barbless hooks, is not statistically different than with barbed hooks. Barbless hooks are applicable to all species and all areas.

There is no significant incremental cost to license holders of using barbless hooks and, given minor impacts on catchability, this selective fishing measure would have no impact on economic viability. No additional labour is required to implement barbless hooks (which were mandatory in 1998).

Barbless hooks are both manageable and enforceable from DFO's perspective. There is no incremental cost to DFO.

Barbless hooks do not lend themselves to any cost recovery measures.

Large Plugs

A plug is a lure (typically a fake herring). The plug lure is constructed so that it spins through the water when trolled behind a fishing vessel, imitating the movement of a wounded herring. One or two hooks (single or tandem rig) hooks are attached to the plug that snag the fish when it strikes the lure. If the plug is large, the fish is less likely to get its mouth all the way around the lure and will therefore be more likely to be snagged in the outer mouth area. If the plug is small, the fish will be more likely to swallow it, thereby sustaining gill damage or incurring serious bleeding often associated with deep mouth wounds. Thus, plug size is thought to be directly related to post-release survival rates. Catchability of a large plug is, for the same reasons, thought to be somewhat lower than a smaller plug: fish that swallow a lure don't get away.

The impact of large plugs on catchability and selectivity needs further testing to prove effective. Large plugs are applicable to large (adult) fish but should otherwise be usable around the province.

License holders could incur some minor capital costs for new gear but operating costs would remain unchanged. Impact on economic viability is unknown (more testing is required) but would be expected to be minor (so long as catchability is not significantly reduced). No additional labour is required to implement this selective fishing measure.

Large plugs are a gear restriction. DFO manages and enforces a variety of gear restrictions every year, thus no significant manageability or enforceability problems are anticipated. There would be no sig-

nificant incremental cost to DFO. Large plugs are not especially suited to cost recovery measures.

Depth Release Hook Covers

Depth release hook covers are simply an idea at this time. They were rejected by the DFO/MoF evaluation team in July as being unenforceable. They are unlikely to be the subject of further investigation in the foreseeable future.

If depth-release hook covers were to be considered further, they would require design and field testing before their impacts on catchability and selectivity would be known with sufficient certainty. This selective fishing measure would be applicable province-wide to species that tend to swim at greater depths.

License holders would incur some minor incremental capital costs for purchase of new gear. Impacts of depth release hook covers on economic viability would not be expected to be significant but more work would need to be done to assess impacts on catchability and consequently on economic viability. No additional labour would be required to implement this selective fishing measure.

This selective fishing measure was rejected as being unenforceable. This could translate into unacceptable costs to DFO should depth-release hook covers be recommended as a selective fishing measure for the troll fishery. They are not considered especially amenable to cost recovery.

Dipnets

Use of dipnets to transfer hooked fish from the water to revival tanks would have no impact on catchability but could improve post-release survival of non-target species. More work is needed to improve understanding of the potential contribution of dipnets to successful selectivity. Dipnets would be applicable to all species and in all areas of the coast.

License holders would incur incremental capital costs to purchase dipnets but these would not be large. Impact on economic viability is

therefore expected to be minimal. No additional labour is required to use dipnets.

Dipnets would be both manageable and enforceable, and would not incur additional costs for DFO. Dipnets are not particularly amenable to cost recovery. They could be easily implemented in the commercial troll fishery.

Release Techniques

Release techniques (in-water vs from tanks) need more work to assess impact on post-release survival. They have no impact on catchability. Release techniques are applicable to all species and in all areas of the coast.

There are no cost implications of using proper release techniques and therefore no impact on economic viability. Additional labour might be required to implement any release techniques but the focus here is on the relative merits of alternative release techniques and no differential labour impact has been noted between alternative release methods.

Release techniques are manageable but universal application could be difficult to enforce. Observers would significantly improve monitoring of correct release techniques. Release techniques could be subject to mandatory training and certification. Course costs could be recovered by charging license holders and crew for courses. Successful completion of an approved course on release techniques could be made a condition of license.

Revival Boxes

Revival, or resuscitation, boxes are used for temporarily holding non-target species that are too stressed to release immediately back to the ocean.

The full impact of revival boxes in the troll fishery still requires some further experimental work to establish. The relative merits of immediate in-water release (ie, without taking the fish on-board) and revival tanks also need to be investigated. Revival boxes are applicable to all species and could be used in all areas.

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License holders have already incurred new costs to purchase revival boxes which were made mandatory in the 1998 fishery. There is no incremental operating cost or labour requirement although revival boxes do increase the amount of time required to complete a set. This work can be done by the existing crew.

Experience with revival boxes indicates that they are both manageable and enforceable. This selective fishing measure imposes no new incremental costs on DFO.

Summary

Test results from experiments with barbless hooks have shown a small improvement in post-release mortality. Time and area closures, likewise, are generally considered to have a positive impact on selectivity. Both these measures have been tried in the troll sector over the course of a number of years. There is fleet familiarity with them and minimal management or enforcement obstacles to implementation. These two selectivity measures, as a result, are readier for near-term implementation than the others under evaluation.

Plug modifications and use of dipnets are all seen as possible, even likely, to improve post-release survivability of non-target species. Each of these measures is also amenable to implementation given that vessel capital and operating costs, and incremental DFO costs, associated with each are low. Further testing in each cases is needed and justified.

Depth release hook covers were rejected as being unenforceable. They are unlikely to be the subject of further investigation in the foreseeable future.

Handling and release techniques, and revival boxes, need more work to assess their impact on gear selectivity. They also pose greater potential enforcement problems. It may be necessary to consider different ways of implementing the measure and motivating compliance. A handling certificate might provide one solution.

Alternate Gear Measures

Alternate gears are drawn from history, and from experience with what has worked in more recent times. Alternate techniques evaluated for readiness for implementation are listed and defined below:

MEASURE	DESCRIPTION
Fish traps	Floating and stationary net cages
Fish wheels	In-river devices for scooping the fish live from the water
Beach seines	Seine nets pulled by hand onto the shore
Fish weirs	Systems of fences that trap fish for selection and harvest
Dip nets	A single net on a pole
Reef nets	Set in front of migrating fish and lifted from the water

Fish traps

Well designed fish traps can be very selective and can be used to release virtually any species. Traps are used extensively in other parts of the world and in some locations catch considerable quantities of fish (eg, in Japan about one-half of up to 40 million salmon are caught by trap).[1]

The ability of traps to catch fish is highly site and design specific. A trap working well in one site might not be transferable to another. Of the various experiments in the past few years, catchability rates have varied widely, but in 1998 most catch rates were low due to some combination of design problems, lack of experience, tide fluctuations, water depth, predation and low abundances coast-wide and especially at the time experiments were conducted. As a result of these factors, and because traps are site selective, the overall effectiveness of a trap cannot be known until it is installed and operated for a number of years.

Capital costs range from $5-25 thousand for floating traps, and $15-100 thousand for stationary ocean traps. Operating costs also

[1] Curry (1998b).

vary, depending on the complexity of the trap and the crew required. Despite historic successes, a long period of time has passed since there was wide spread knowledge of trapping techniques and good trapping locations. As a result, today (with catchability unknown at any given location) it is very difficult to predict the likely economic viability of a proposed operation without experimenting.

Traps present major management challenges, requiring consideration of issues such as licensing, allocation and enforcement. The likely implementation cost to DFO would be high. A trap is a discrete operation, and DFO should be able to quantify its incremental costs and achieve cost recovery more easily than with fleet wide measures.

The ease of implementing traps will vary widely by group and location. Some First Nations have a long history of experience with traps, and have been able to pass down expertise from generation to generation. Other groups and individuals would have to learn the peculiarities of their chosen site, and of the gear itself, before their efforts might be rewarded. Traps are conducive to tagging, enumeration and sampling activities.

Fish wheels

Fish wheels, like fish traps, can be highly selective regardless of the species involved. Their ability to release fish in good condition after capture has been demonstrated in a number of different experiments, in both the north and the south. The ability of a given fish wheel to catch fish in large numbers, however, is highly site specific. Water clarity, water depth and current, floating debris, shoreline configuration and shore access all contribute to the success or failure of a wheel.

Since different site characteristics will require quite different wheel characteristics, costs vary widely from $10-40 thousand. Economic viability, in part as a result of this, is difficult to predict without testing.

Fish wheels present major management challenges, requiring consideration of many issues such as licensing, allocation and enforcement. The likely implementation cost to DFO would be high. Fish wheels are discrete operations, and DFO would have the ability to quantify

its incremental costs associated with a given wheel. For this reason, cost recovery might be easier than with fleet-wide measures.

The ease of fish wheel implementation will vary widely by group and location. Those with expertise and good sites will be able to implement fish wheels more easily than other groups. There has been extensive experimentation in the past five years, however, and the community body of knowledge, province-wide, is growing. The wheel is a live-capture technique well suited to assisting with tagging, enumeration and sampling activities, and might throw off knowledge benefits as well.

Beach seines

Beach seines can be very selective across species, although this will vary from operation to operation. Beach conditions, education in handling practices, the presence or absence of revival boxes, and the method by which the beach seine is pulled ashore (power vs. manual) all have an effect on the survival of non-target species. Like other alternative gears, their catchability is highly site specific, dependent on beach and river-bottom characteristics, primarily.

A beach seine can cost up to $10,000 and take 6-10 people to operate. It typically requires a herring skiff or similar vessel ($30,000) to deploy the gear in a river. Economic viability will depend on the amount of fish that can be captured at the location in question, and also on the quality of these fish (since beach seines are typically used in-river).

Beach seines offer some of the same management challenges as do fish traps and wheels. They raise the same issues of licensing, allocation and enforcement, and lend themselves to cost recovery in the same fashion. Certain First Nations have a long acquaintance with beach seine operations, and in these instances, implementation would be somewhat easier. There is a potential environmental impact on river-bottom species from using beach seines, but this has not been the subject of much recent formal study.

Fish weirs

Fish weirs can be a highly selective means of live capture. They are not species specific, but site specific, requiring unique design for any given spot. Assuming the site lends itself to the construction of a weir, these fences typically have high catchability.

Weirs cost from $6-10 thousand to build and require 2-4 people to operate. In a suitable site, weirs are likely to be economic viable, although fish quality will remain a factor in the value of fish sold from in-river locations.

Similar management issues arise with weirs as with other discrete selective gears—licensing, allocation and enforcement—and their amenability to cost recovery is high.

Weirs are particularly useful in enumerating escapement to different river systems, and could be used to help with tagging and sampling efforts. Environmental impacts are thought to be limited.

Dip nets

Dip nets are a highly selective method of removing fish from passing river waters. In good water conditions, and assuming operators know the appearance of the different species, they can avoid encounters with non-target species entirely. Even if a non-target fish is captured, it can be quickly released. This technique has proven itself to have very high catchability, particularly when used in narrow channels or at counting fences.

Dip nets are not expensive—a dip net is estimated to cost $100—and thus are very likely to be economically viable in the right locations.

Dispersed, new dip net operations would present the same management issues as traps, wheels and beach seines. In practice, however, dip netting is frequently implemented at existing DFO counting fences (eg, the Babine fence and the Morristown Canyon fish ladder). Regarding enforcement, there would be high costs to monitor a dip net fishery because many individuals would be fishing in many locations. To the extent that there are incremental costs to DFO in mounting a dip net operation, the measure is as amenable to cost recovery as other alternative gear types.

Environmental impacts of the dip net are very low.

Reef nets

There is somewhat less experience in BC with reef nets than with other alternative gear types. Where this expertise is found (eg, Washington State) the technique can be highly effective and selective. Experiments from this year in BC, however, were inconclusive. Like other alternative gear measures, reef nets are applicable to all species but are very site-specific. Tide and current conditions are particularly crucial to success.

Costs can vary widely depending on the type of vessels and the number of crew used, but at the low end, a single net with leads, two vessels with outboard power, and two people are required.

Similar management issues arise with reef nets as with other remote selective gears—licensing, allocation and enforcement—and the amenability to cost recovery is high. Reef nets are likely not as useful as other measures in enumeration, tagging and sampling, given that they take place at sea and non-target species are typically released immediately at capture and not held. Environmental impacts of the technique are thought to be limited.

Summary

The alternate measures evaluated in this section look very much the same in some respects. They each hold high promise for selectivity and applicability to all species, while being highly site-specific and dependent on the unique characteristics of their site for catchability.

Costs range from very low (dip nets) to very high (some stationary fish traps), and in every case some capital and incremental labour investment is involved. Economic viability—with the exception of dip netting at known sites—is very difficult to predict without experimentation.

Each measure presents challenges to management in the areas of licensing, allocation and enforcement. However, insofar as these measures are implemented in discrete operations at known sites,

they are more amenable to cost recovery than would be the case with some fleet-wide measures.

Ease of implementation depends, again, on the site and people in question. Where there is local expertise and an appropriate local site, these measures will be the easier to introduce. Dip nets are probably the easiest in this regard, being suitable in a wide range of sites and well known to many First Nations in the north and south. Reef netting and fish trapping probably require the greatest amount of continued testing.

Recreational Measures

Recreational selectivity measures are drawn from experimentation of fishermen and DFO, with a focus on measures that have been tested in recent years. Measures over this period have tended to fall into two groups, management measures designed to reduce encounters (ie, achieve selectivity objectives by avoidance), and gear and fishing technique modifications that are intended to reduce both encounters and post-release mortalities. These measures are grouped and briefly defined below.

Measured against three of our evaluation criteria—labour impacts, cost recoverability and incremental environmental cost—these measures are all very similar. None requires that commercial lodges add additional crew. None lends itself more easily than others to cost recovery, and the environmental impact of each is very small. We focus our evaluation on the remaining criteria.

GROUP	MEASURE	DESCRIPTION
Managing for avoidance	Time/area closure	Opening and closing fisheries to harvest "clean" stocks and avoid stocks of concern.
	Cooperative avoidance	Communicating high non-target species encounter rates so that effort can be (voluntarily) shifted to alternate areas
Gear and technique modification	Barbless hooks	Easier to remove without damaging the fish
	Tandem vs. single hooks	The impact of different bait rigs
	Mooching vs. trolling	The impact of different fishing techniques

Managing to avoidance

The impact of time/area closures is similar in the recreational sector as it is in the commercial sectors. The avoidance selectivity of the measure is considered high, although over time this measure will limit the catchability of the sector (assuming that fishing opportunities lost due to closures are not made up by increased opportunities to fish elsewhere). The measure is applicable to all species and can be implemented coast wide.

From an economic standpoint, there is no incremental capital cost to the recreational fleet of time/area closures, although the operating costs of guides and lodges might rise if they were required to take their clients longer distances to suitable fishing areas. Their operating costs as a ratio of revenues might also rise if the days fished per season fell.

The management implications of the measure could be significant. Where the use of time/area closures is increased significantly relative to their use in the past (as in 1998 with the introduction of yellow and red zones), considerable pre-season communication with stakeholders is required, as well as planning and additional enforcement.

Beyond these management implications above, time/area closures are considered relatively easy to implement. Stakeholder familiarity with the measure is high, and it imposes no change in the manner of fishing once fishing does commence.

The cooperative avoidance strategy pursued by DFO and various commercial lodges this year is distinct from time/area closures because, while it focussed on avoidance selectivity, it sought to do so without reducing the catchability of the fleet. When high encounters with coho were detected in a given sub-area, this information was passed on to commercial lodges (in the Queen Charlottes, specifically) which had been asked informally to redirect their fishing effort to other areas until coho abundance fell. It is difficult to assess the true selectivity of this measure. The strategy was ad hoc, not formally measured, and compliance is difficult to know precisely. Results from 1998 suggest that the program did increase the selectivity of the fleet, although more so for guided vessels than for non-guided vessels. In theory, at least, this kind of measure should be applicable to any species and might be implemented anywhere on the coast.

The economic cost of the measure, to lodges and guides, would be similar to time/area closures. Operating costs might rise if further travel is required, and they might rise relative to revenues if the lodge is able to fish fewer days in a season as a result of the restriction.

In terms of management, the measure is unconventional in the sense that it is voluntary and ad hoc. DFO undertakes to communicate the location of coho abundances to the lodges; they in turn make their guests and guides aware of the areas to avoid. Although it is difficult to confirm whether communications are getting through to the lodge guests, there is no obligation under this kind of project to enforce or manage differently as a result. One would expect communication costs to the DFO to rise, although not greatly.

Both avoidance management measures are relatively easy to implement, although for different reasons. Time/area closures are known to the fleet, and although there is always a degree of resistance to limiting the fishing season, there is some acceptance of closures as long as they are communicated clearly. The ad hoc avoidance strategy would likely meet with little resistance because of its voluntary 'best-efforts' quality. The knowledge returns of this measure are limited, given the ad hoc nature of the project, where no confirmation of results is undertaken.

Gear and technique modification

We look at three gear and technique issues in this section: barbless hooks, the use of cut-plug single vs. cut-plug tandem bait rigs, and mooching vs. trolling.

From the standpoint of management, these measures are all very similar. They are measures that fit within the existing management framework but might well require significant additional enforcement expenditures if made mandatory across the entire recreational fleet—commercial lodge operations and anglers. With this point in mind, we look at these gear and technique modifications in light of their effectiveness, economic viability and ease of implementation.

Barbless hooks decrease the catchability of a given set of gear by allowing the fish to escape more easily. They are also thought to increase the selectivity of the gear by being more easily removed from

the mouth of a captured fish—this might minimize handling time and mouth injury—however no formal testing evidence exists to support this impression. The barbless hook can be presented in a variety of ways, and is not considered species-specific. Barbless hooks could be used anywhere on the coast. The incremental cost is minor, and barbless hooks are therefore considered to be economically viable. Given that the fleet has some familiarity with this measures already, it is considered relatively easy to implement.

Cut plug bait rigs are the dominant fishing method in some areas and considered highly effective. In experiments at Work Channel in 1998, tests were carried out to determine the selectivity of single versus tandem rigs. Results suggested that there was little difference in post-release mortalities between the two gears. However, the 1998 experiment involved mooching and a significantly higher post-release mortality rate was recorded than in experiments from the early nineties that employed a slow troll. Results are not conclusive at this point, but some believe that the post-release mortality of coho (and other species) will rise with the number of 'swallow' captures, where the fish takes the hook into its throat (and increases the risk of bleeding and gill damage). Since swallow captures are thought also to rise the slower the bait is moving through the water, there is some anecdotal evidence to support the contention that mooching is somewhat less selective than slow trolling.

Mooching and trolling are quite similar in some other respects. Catchability is area specific, no one fishing technique works coast wide. There is no incremental cost to the angler if either measure is implemented, and the overall economic viability of either measure is considered high. Enforcing fishing techniques such as these would offer some new enforcement challenges, however, and incremental cost to the Department of making either of these measure mandatory would likely be high.

Summary

Avoidance strategies in the recreational fishery were a very significant part of the selectivity effort in 1998. This is in part due to the nature of the fleet. With many individual anglers, mandatory gear and technique measures present compliance and enforcement issues and, likely, additional costs.

Of the two avoidance strategies, time/area closures are the more developed and formalized method. Use of this measure is thought to have contributed significantly to selectivity this year, while the impact of co-operative avoidance strategies is less clear. Formal testing of the co-operative strategy might resolve this issue, or suggest ways in which accountability could be ensured.

Of the gear and technique modifications, the barbless hook has high acceptance among recreational fishermen, and it is considered highly implementable in the near term. Technique modifications such as mandatory slow-trolling, for example, would be much more problematic. Evidence suggesting that mooching might be less selective than slow-trolling is preliminary, and enforcing such a mandatory measure coast and fleet-wide would be involved and costly.

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